A Night-Owl's Guide to Galaxies

ASTRONOMY®

June 1996 U.S. $3.95
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Tiny Galaxies Rule the Universe

Hooray for Comet Hyakutake!

Asteroids: The Geology of Microworlds

See Jupiter at its Best

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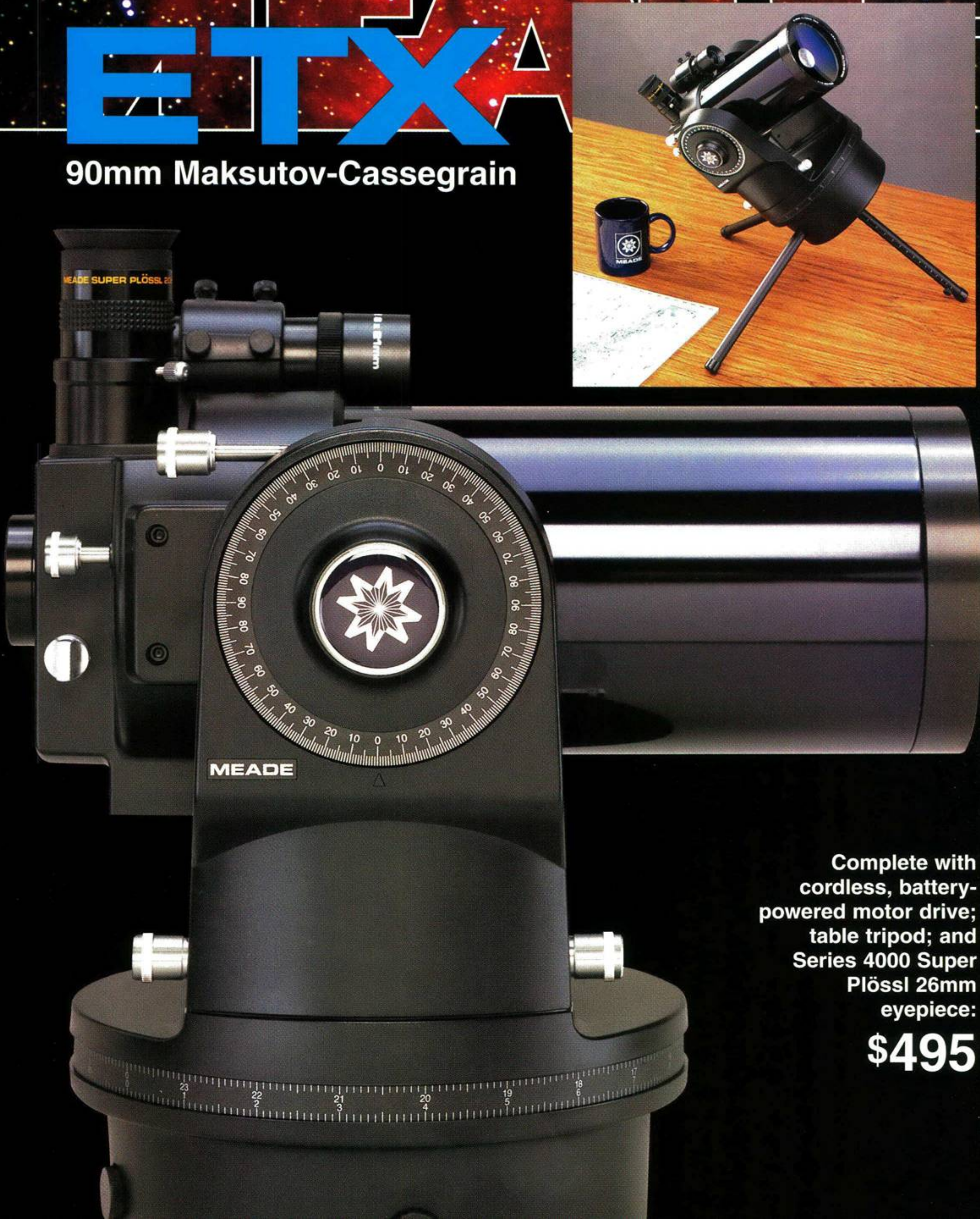
ETX

90mm Maksutov-Cassegrain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Complete with cordless, battery-powered motor drive; table tripod; and Series 4000 Super Plössl 26mm eyepiece:

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Now you can have the exquisite, diffraction-limited imaging and ultraportability of a 90mm Maksutov-Cassegrain...*at only $495*, *complete!*

Meade technology has just made it possible for you to own a telescope that, only a few years ago, would have cost over $2000.

The revolutionary Meade ETX™ goes anywhere with you at a moment's notice and presents the finest optical images—*bar none*—ever made available in an ultraportable telescope.

From its stunningly beautiful, deep-violet, polished-aluminum optical tube to its precision internal flip-mirror system, the ETX is as unprecedented for its fit and finish as for its breathtaking optical performance. For the casual or beginning observer, the Meade ETX may be all the telescope ever required. For the advanced observer who already owns a larger instrument, the ETX is the perfect ultraportable field telescope.

- **Optical System:** Manufactured entirely at the Meade Irvine facility, ETX Maksutov optics produce stellar diffraction images virtually identical to those of the finest apochromatic refractor. *Optical performance and resolution warranted to equal or exceed any Maksutov optics of similar aperture ever manufactured at any price, past or present.* Optics so high in contrast, image brightness, and resolution that the ETX consistently outperforms many telescopes of larger apertures.

- **Materials and Coatings:** ETX optics include a Maksutov corrector lens of Grade-A BK7 optical glass, individually matched to a hand-figured Pyrex® primary mirror. Meade Super Multi-Coatings on all optical surfaces maximize light transmission and image contrast.

Eyepiece-end of the ETX, showing Flip-Mirror Control, Focus Knob, R.A. Slow-motion and Lock, Dec. Slow-motion and Lock.

- **Cordless Motor Drive:** The cordless, internal motor drive system operates from three AA-size batteries that power the telescope for more than 50 hours. A North-South switch permits drive operation anywhere in the world.

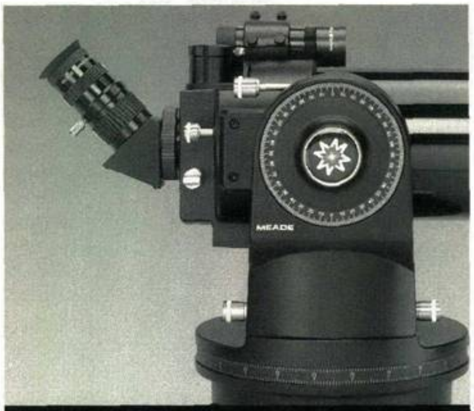
- **Flip-Mirror System:** Flip the internal optical-flat mirror "up" for observing in the standard 90° position; flip the mirror "down" for terrestrial observing with the optional #932 45° Erecting Prism or for photography with the optional #64 Photo-Adapter.

Attach the optional #64 Photo-Adapter for through-the-telescope photography with your 35mm camera.

- **Equatorial Fork Mount:** Precise polar alignment in *seconds,* just by extending the center tripod leg to read your latitude on the leg's inscribed scale. Slow-motion controls in both R.A. and Dec. permit smooth manual tracking of terrestrial or astronomical objects; release the manual controls and automatic astronomical tracking is engaged through the motor drive.

- **Standard accessories** include a Meade Series 4000 Super Plössl 26mm eyepiece and 8 x 21mm *erect-image* viewfinder.

- **Optional accessories** include a Soft Carry Bag with shoulder strap (suitable for ETX hand-carry aboard an airplane); #64 Photo-Adapter; #932 45° Erecting Prism (standard with ETX Spotting Scope), and more than 20 eyepieces for powers from 31X to over 300X.



Use the optional #932 45° Erecting Prism for high-resolution terrestrial observing.

SPECIFICATIONS

ETX Astro Telescope—Includes Maksutov-Cassegrain optical tube assembly (D = 90mm, F = 1250mm, f/13.8) with EMC super multi-coatings; internal flip-mirror system for either straight-through or 90° observing position; equatorial fork mount with slow-motion controls, locks, and setting circles in R.A. and Dec; table tripod with elevation scale on center tripod leg; motor drive system with internal battery compartment accepting three (user-supplied) AA-size batteries; 8 x 21mm achromatic erect-image viewfinder; Series 4000 Super Plössl 26mm eyepiece (1.25"); operating instructions. *Net weight 9 lbs.*

$495 (+ $20 packing and shipping in the 48 states)

ETX Spotting Scope—Includes Maksutov-Cassegrain optical tube assembly (D = 90mm, F = 1250mm, f/13.8) identical to tube assembly of ETX Astro Telescope, with EMC super multi-coatings; internal flip-mirror system for either straight-through or 90° observing position; #932 45° erecting prism; 8 x 21mm achromatic erect-image viewfinder; Series 4000 Super Plössl 26mm eyepiece (1.25"); adapter block for attachment to standard (1/4-20) photo tripods; operating instructions. *Net weight 3 lbs.*

$395 (+ $10 packing and shipping in the 48 states)

Prices listed are suggested U.S. mail-order retail prices.

AUTHORIZED U.S. MAIL-ORDER DEALERS

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Orders: 800-422-7876; Info.: 405-364-0858.

CALIFORNIA TELESCOPE COMPANY, Burbank, CA.
Orders & Information: 818-505-8424.

FOCUS CAMERA, Brooklyn, NY.
Orders: 800-221-0828; Info.: 718-436-6262.

LUMICON, Livermore, CA.
Orders: 800-767-9576; Info.: 510-447-9570.

RIVERS CAMERA, Dover, NH.
Orders: 800-245-7963; Info.: 603-742-4888.

SHUTAN CAMERA & VIDEO, Chicago, IL.
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ASTRONOMY®
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THE COMET OF THE DECADE, so far at least, transfixed observers around the globe this spring. For more stunning images of the great Comet Hyakutake, see page 76. Photo by Andrew Druga.

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BEHIND THE SCENES

Magnificent Milky Ways

Edward Barnard did something a lot of backyard observers would love to do. Starting with only a modest education but megawatts of drive, he clawed his way high into the ranks of professional astronomy. How he did it was interesting. He didn't tackle the pros on their own turf, which in his day was just as heavy with mathematics as it is now.

Instead, Barnard pushed a known technology — photography — to the limits of the possible. A highly skilled visual observer, he nonetheless understood that astronomy desperately needed to go beyond what the eye could glean at the eyepiece. And his instinct was dead right. As Martin Harwit notes in his book *Cosmic Discovery*, every time astronomers make detectors more sensitive or expand their range in wavelength, fundamental discoveries pop forth immediately. A perfect case in point is the dark interstellar matter that Ed Barnard was the first to photograph systematically.

E. E. Barnard/Yerkes Observatory

Amateur astrophotography.

A true understanding of our galaxy's nature had to wait for the work of Heber Curtis, Harlow Shapley, and Edwin Hubble in the 1920s and 30s. But by recording the Milky Way's complexity in unprecendented detail, Barnard pointed the way and in the process uncovered an immense variety of galactic features (p. 32). Most were unknown or sensed only dimly before his work.

Long before, Galileo had discovered that the Milky Way was made up of stars. But who ever suspected the gas and dust clouds of Rho Ophiuchi? (For today's view, see p. 68.) Or the tight, dark nebulae that snake through Sagittarius and elsewhere? Barnard's images were outstandingly beautiful — and pathbreakers for science.

Could a Barnard emerge today? Probably not. The strategy he used, translated into today's terms, would demand funding on a national scale, and it's hard to imagine an amateur who'd qualify. But I'll bet there's room yet in astronomy for fundamental discoveries by non-professionals. And I'll make a further bet that when such a discovery does arrive, it'll come from the ranks of the CCDers — but that's a topic for another day!

Sincerely,

Robert Burnham
Editor
rburnham@astronomy.com

LETTERS

Close Encounters of the Text Kind

Thanks for running Jeff Kanipe's review of *Close Encounters of the Fourth Kind: Alien Abductions, UFOs, and the Conference at M.I.T.* by C. D. B. Bryan (January 1996). It's a book I normally wouldn't have bothered picking up if not for the review. Though I am a skeptic, I now find myself sympathetic toward those who experience such things. Through reading the book it becomes painfully obvious that these troubled people have something profound happening to them, though it may be past traumatic experiences rather than visits by aliens from the Andromeda Galaxy.

What I think we need to do as skeptics is stop thinking of these people as "loonies" and show a bit more compassion toward their ordeals. — *Joseph Almanzo, Waukegan, Illinois*

ASTRONOMY®

Editor	**Robert Burnham** rburnham@astronomy.com
Managing Editor	**Jeff Kanipe** jkanipe@astronomy.com
Associate Editor	**David J. Eicher** deicher@astronomy.com
Associate Editor	**David H. Bruning** dbruning@astronomy.com
Associate Editor	**John Shibley** jshibley@astronomy.com
Associate Editor	**Robert Naeye** rnaeye@astronomy.com
Associate Editor	**Richard Talcott** rtalcott@astronomy.com
Editorial Assistant	**Tracy Staedter** tstaedter@astronomy.com
Editorial Secretary	**Julie Sherwin** jsherwin@astronomy.com
Art Director	**Thomas L. Hunt** thunt@astronomy.com
Graphic Designer	**Katherine Kolstedt**
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Advertising Sales Manager	**Dan Koehler** dkoehler@astronomy.com
Advertising Sales Representative	**Debbi A. Simon** dsimon@astronomy.com
Advertising Services Representative	**Mary Reynolds** mreynolds@kalmbach.com
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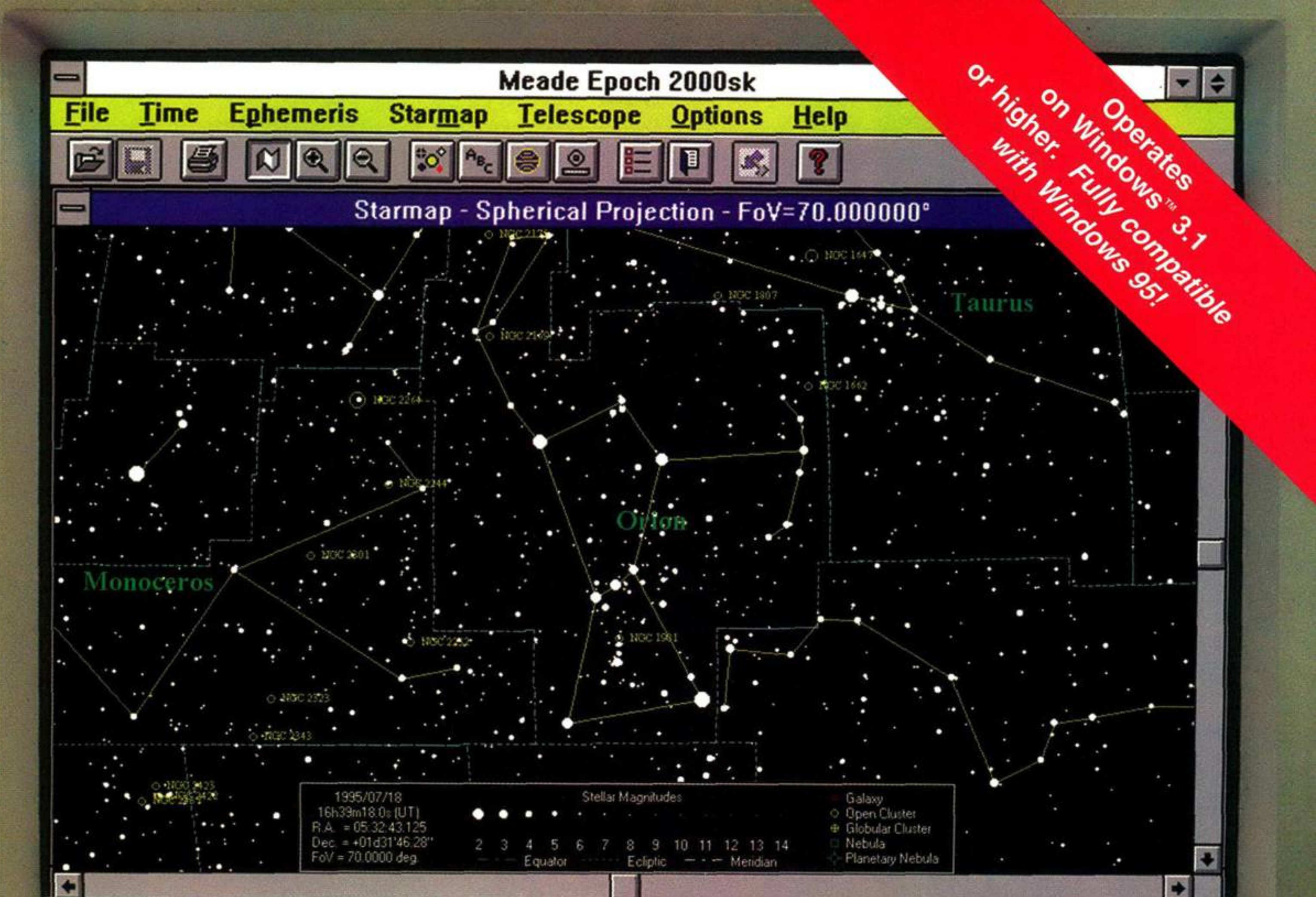
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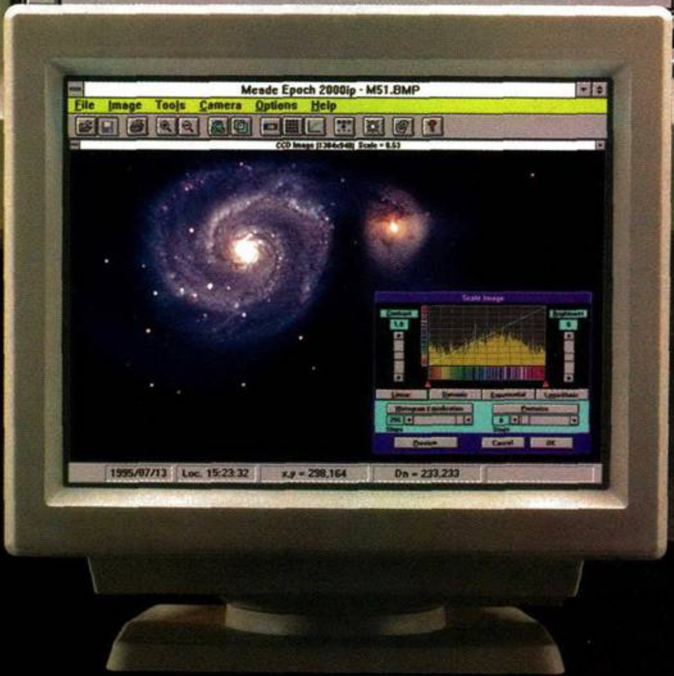
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Epoch 2000sk *(above)* displays stars, planets, asteroids, and comets accurate in position to an *arc-second* level, the most precise position display of any sky software yet developed.

MEADE® EPOCH 2000®

The most powerful astronomical software ever made available can now be yours for only $149!

Now you can use the most precise sky software ever created, to zoom-in on telescopic fields **smaller than one arc second!** With star positions displayed as precisely as **0.01 arc second,** no longer is the Trapezium in Orion, for example, shown as a single point as in other software, **but as four precisely oriented starpoints, just as they appear in the telescope.** No longer do you need to guess the R.A. and Dec. of an object located away from the field center, as in other programs: Epoch 2000sk dynamically reads out the R.A. and Dec. of the cursor position anywhere in the field **and updates R.A. and Dec. instantaneously as the cursor is moved about the field.** LX200 owners can use Epoch 2000sk for remote auto-centering of objects in the telescopic field **to a precision of 30 arc seconds,** routinely!

Send for your free copy of **Meade Bulletin 2000.** See why, if you're serious about astronomy, Meade Epoch 2000sk is the only sky software to use!

EPOCH 2000sk Sky Software: 281,000 objects supplied on 3.5" discs for Windows 3.1 or higher **$149**

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LX200 Interface Cable: for Meade LX200 operation by Epoch 2000sk . . **25**

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10" LX200
12" LX200
7" LX50
8" LX50
10" LX50
4" ED/APO
5" ED/APO
Starfinder Equatorial 6"
8"
10"
6" ED/APO
7" ED/APO
16"
Starfinder Dobsonian 6"
8"
10"
12.5"
16"
STARFINDER MEADE

Price increase effective June 1, 1996

Current Meade telescope prices have been extended through May 31 and will not be extended further. New higher prices listed below are effective June 1.

Over the past five years the Meade Instruments factory in Irvine, California, has been continuously updated into one of the most modern, most efficient facilities in the world for the manufacture of precision astronomical instrumentation. This utilization of the very latest in high-technology equipment—in Meade optical fabrication and coating rooms, in the machining department, in telescope testing and quality assurance, and in instrument assembly—has enabled us to maintain stable pricing levels for the great majority of the more than two dozen astronomical telescope models that we manufacture. In some cases prices for Meade telescopes have not increased in more than three years, despite numerous technical improvements that have been put in place on every model during that period.

We believe that Meade LX200's, LX50's, ED/APO's, and Starfinder Equatorials and Dobsonians represent the very best in American technology—a fact confirmed every day by the large numbers of Meade telescopes that we export around the world. In spite of the formidable pricing competition that we face in many foreign countries, Meade astronomical telescopes have attained a predominant position in virtually every country.

Notwithstanding the success that Meade Instruments has achieved, a success for which we are profoundly grateful to amateur astronomers in the United States and worldwide, even Meade technology and manufacturing efficiency have their limits. It is for these reasons that the prices of Meade astronomical telescopes must undergo a general price increase.

We are making this advance announcement of the June 1, 1996, price increase in order to offer a final opportunity for our customers to purchase a Meade telescope at current prices. Even at their new prices, listed below, Meade telescopes will still represent, by far, the finest values available in quality astronomical instrumentation.

Price increase announcements, however uncommon they may be at Meade Instruments, normally result in a substantial increase in our manufacturing backlog. We therefore urge an early purchase of the Meade model you are considering, to avoid a long waiting period.

Meade Telescope Model	***Current Price through May 31, 1996***	***New Price effective June 1, 1996***
8" LX200 Schmidt-Cassegrain	$2495	$2795
10" LX200 Schmidt-Cassegrain	2895	3195
12" LX200 Schmidt-Cassegrain	3995	4495
7" LX200 Maksutov-Cassegrain	2995	3295
8" LX50 Schmidt-Cassegrain	1195	1395
10" LX50 Schmidt-Cassegrain	1495	1695
7" LX50 Maksutov-Cassegrain	1595	1795
4" ED Apochromatic Refractor	2495	2795
5" ED Apochromatic Refractor	2995	3295
6" ED Apochromatic Refractor	4495	4995
7" ED Apochromatic Refractor	5495	5995
Starfinder Equatorial 6	599.95	649.95
Starfinder Equatorial 8	699.95	749.95
Starfinder Equatorial 10	799.95	879.95
Starfinder Equatorial 16	2495	2695
Starfinder Dobsonian 6	325	349
Starfinder Dobsonian 8	425	469
Starfinder Dobsonian 10	595	649
Starfinder Dobsonian 12.5	795	895
Starfinder Dobsonian 16	1095	1195

Prices shown are suggested U.S. national mail-order retail prices, exclusive of any applicable sales taxes or credit card charges, and do not include packing and shipping. Specifications for Meade telescope models are listed in advertisements elsewhere in this magazine issue, or contact your authorized Meade Advanced Products dealer for complete information. The 76-page Meade 1996 General Catalog is available directly from Meade Instruments at $3.00, forwarded by first class mail.

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12"
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8"
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The largest-selling serious telescopes in the world.

In virtually every country in the world where serious telescopes are sold, more Meade LX200's are sold than all competing models ***combined***. Consider these *standard-equipment* specifications:

- **Superb Optics:** LX200 imaging capabilities are a legend in the industry; we regularly receive reports stating that optical performance approaches that of a fine *ED* apochromatic lens.
- **Automatic GO TO Capability:** Meade LX200's are *the only commercial telescopes ever manufactured* that automatically GO TO any input R.A. and Dec., or to any of over 64,350 objects in the onboard database, *to a precision of one arc-minute or better.*
- **Meade LX200 High-Precision Pointing™** is so precise it permits the positioning of *every* selected object on *every* commercially-available CCD chip *every* time, automatically — *a feat that no other telescope priced under $40,000 can accomplish.*
- **Permanently-Programmable Smart Drive™** routinely achieves 5 arc. sec. periodic error, an observatory standard.
- **9-Speed Dual-Axis Electronics:** Electronics that cover every possible contingency of telescope positioning—from 2x photo-guide, to 32x image centering, to 8°/sec. slewing across the sky, as well as 6 other dual-axis drive speeds in between.
- **Field Operation:** No other telescopes of such incredible capabilities transport so readily for field operation. The optional #1812 Electronic DC Adapter (a compact 4 oz. unit) allows for field powering directly from an auto cigarette lighter plug.

SPECIFICATIONS: 7", 8", 10", and 12" LX200's—Each complete telescope includes 8" or 10" (f/6.3 or f/10) or 12" f/10 Schmidt-Cassegrain or 7" f/15 Maksutov-Cassegrain optical tube assembly with EMC super multi-coatings; heavy-duty fork mount with 4" polar ball bearing, dual-axis 5.75" worm gears, and multi-function control panel; manual and electric slow-motion controls on both axes; keypad hand controller with digital readout display, permanently programmable Smart Drive, 9-speed drive controls on both axes (7-speed on 12"), High-Precision Pointing, and GO TO controller; 64,359-object onboard celestial software library; 25 ft. power cord and adapter for telescope operation from 115v.AC; 8 x 50mm viewfinder; 1.25" diagonal prism (7", 8", 10") or 2" diagonal mirror with 1.25" adapter (12"); Series 4000 Super Plössl 26mm eyepiece; standard field tripod (7", 8", 10") or giant field tripod (12"); complete operating instructions.

8" LX200 Schmidt-Cassegrain	**$2495.**
10" LX200 Schmidt-Cassegrain	**2895.**
12" LX200 Schmidt-Cassegrain	**3995.**
7" LX200 Maksutov-Cassegrain	**2995.**

Packing and shipping in the 48 states: 8"—$105; 10"—$145; 12"—$215; 7"—$125.

ADE

LX50

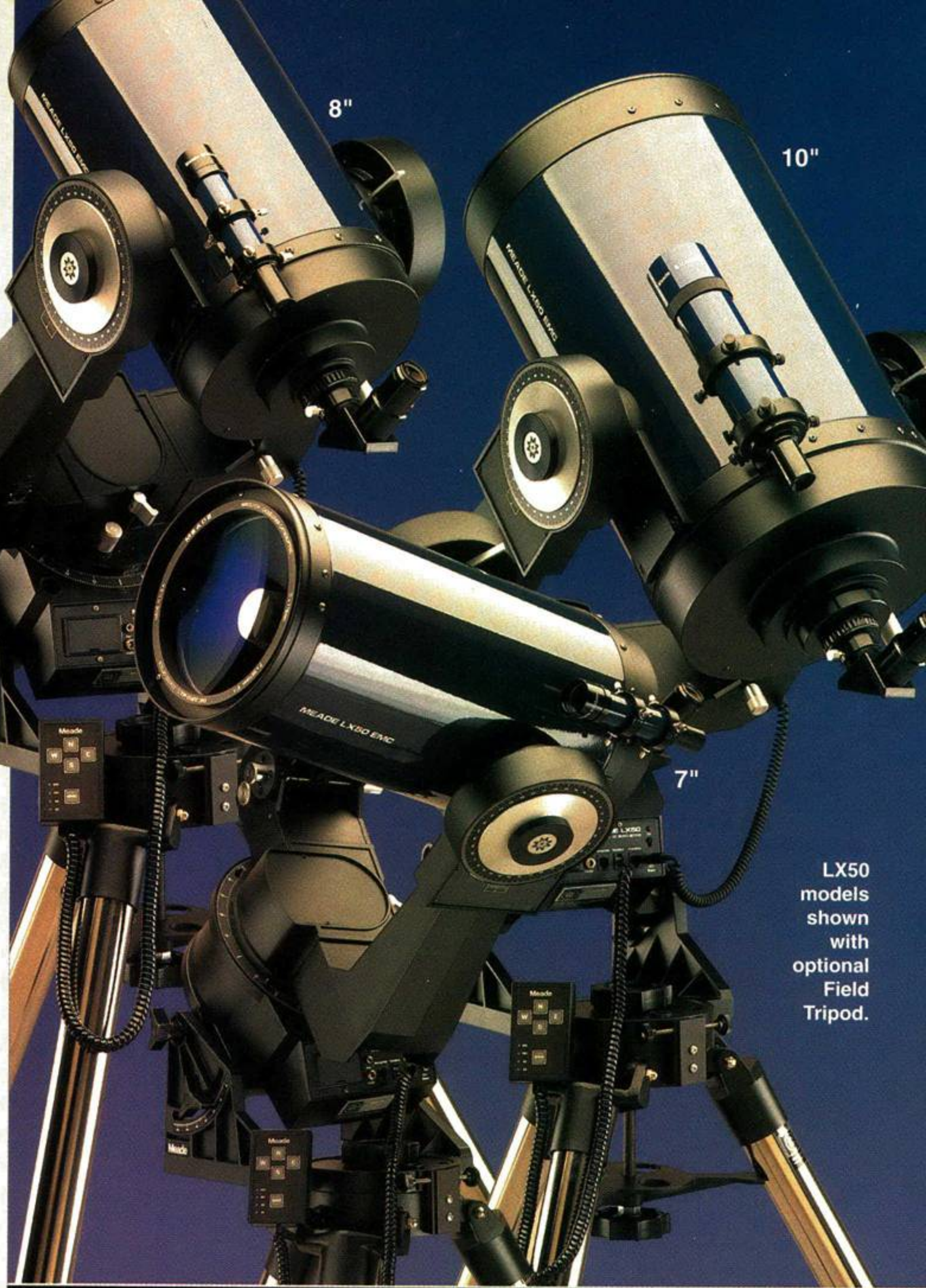
Advanced technology at the most affordable prices ever.

- **Battery-Powered, Completely Cordless Operation!** Meade LX50 models operate for more than 50 hours from four AA-size batteries inserted through the telescope's control panel. Or use the standard-equipment 25 ft. cord to power the telescope directly from any auto cigarette lighter plug.
- **Standard-Equipment Declination Motor and Hand Controller:** Plug the hand controller into the LX50 control panel and you're ready for full dual-axis drive capability at any of 4 photo-guide or microslew speeds: 2x, 8x, 16x, or 32x, plus quartz-controlled sidereal-rate tracking in R.A. Switch speeds instantly using the speed-control button on the hand controller. Dual-axis drive rate is indicated by a red LED.
- **Multi-Function Control Panel:** Includes connectors for CCD autoguiders; for the standard-equipment Declination motor; and for the optional Magellan II Computer-Corrector *(below)*. A North-South switch permits telescope operation anywhere in the world.
- **Super Multi-Coated Optics:** The exact same EMC super multi-coated optical tube assemblies included with Meade LX200 models.
- **Massive LX200-type Fork Mounts:** Meade LX50 mounts are manufactured of the same virgin aluminum castings as Meade LX200 Schmidt-Cassegrains. Massive, rigid mountings that include the Meade LX worm-gear drive system with low periodic error for advanced photographic or CCD imaging applications. *No competing mid-priced equatorial mountings even come close.*

SPECIFICATIONS: 7", 8", and 10" LX50's—Each complete telescope includes 8" or 10" f/10 Schmidt-Cassegrain or 7" f/15 Maksutov-Cassegrain optical tube assembly with EMC super multi-coatings; heavy-duty LX200-type fork mount; 5.75" LX worm gear system in R.A.; multi-function control panel; DC servo Declination motor; manual and electric slow-motion controls on both axes; setting circles on both axes; keypad hand controller; 4-speed drive controls on both axes; battery compartment accepting four (user-supplied) AA-size batteries; 25 ft. power cord for telescope operation from 12v. auto cigarette lighter plug; 6 x 30mm (7" and 8" models) or 8 x 50mm (10") viewfinder; 1.25" diagonal prism; MA25mm multi-coated eyepiece (1.25"); standard equatorial wedge with elevation scale, bubble level, and azimuth control; complete operating instructions.

8" LX50 Schmidt-Cassegrain	**$1195.**
10" LX50 Schmidt-Cassegrain	**1495.**
7" LX50 Maksutov-Cassegrain	**1595.**
Variable-Height Field Tripod	**295.**
7" Maksutov-Cassegrain Tube Ass'y, only	**1195.**

Packing and shipping in the 48 states: 8"—$105; 10"—$145; 7"—$125; 7" Tube Assembly—$65.



LX50 models shown with optional Field Tripod.

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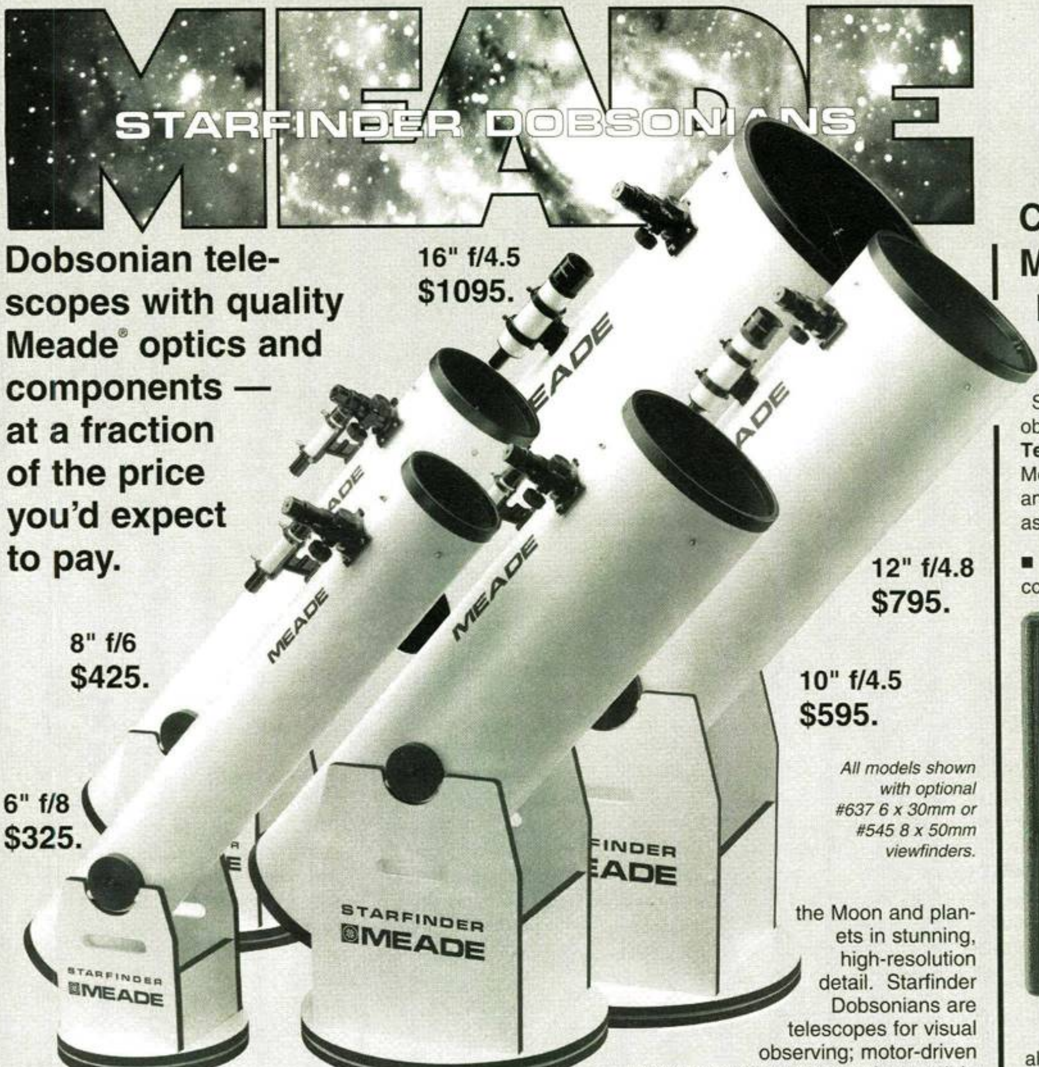

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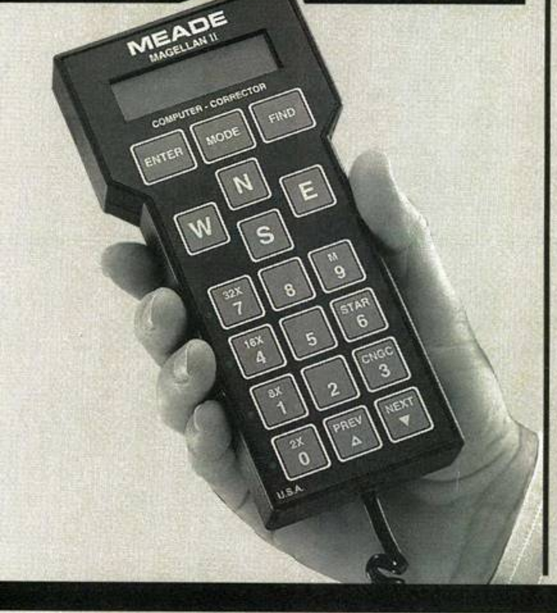

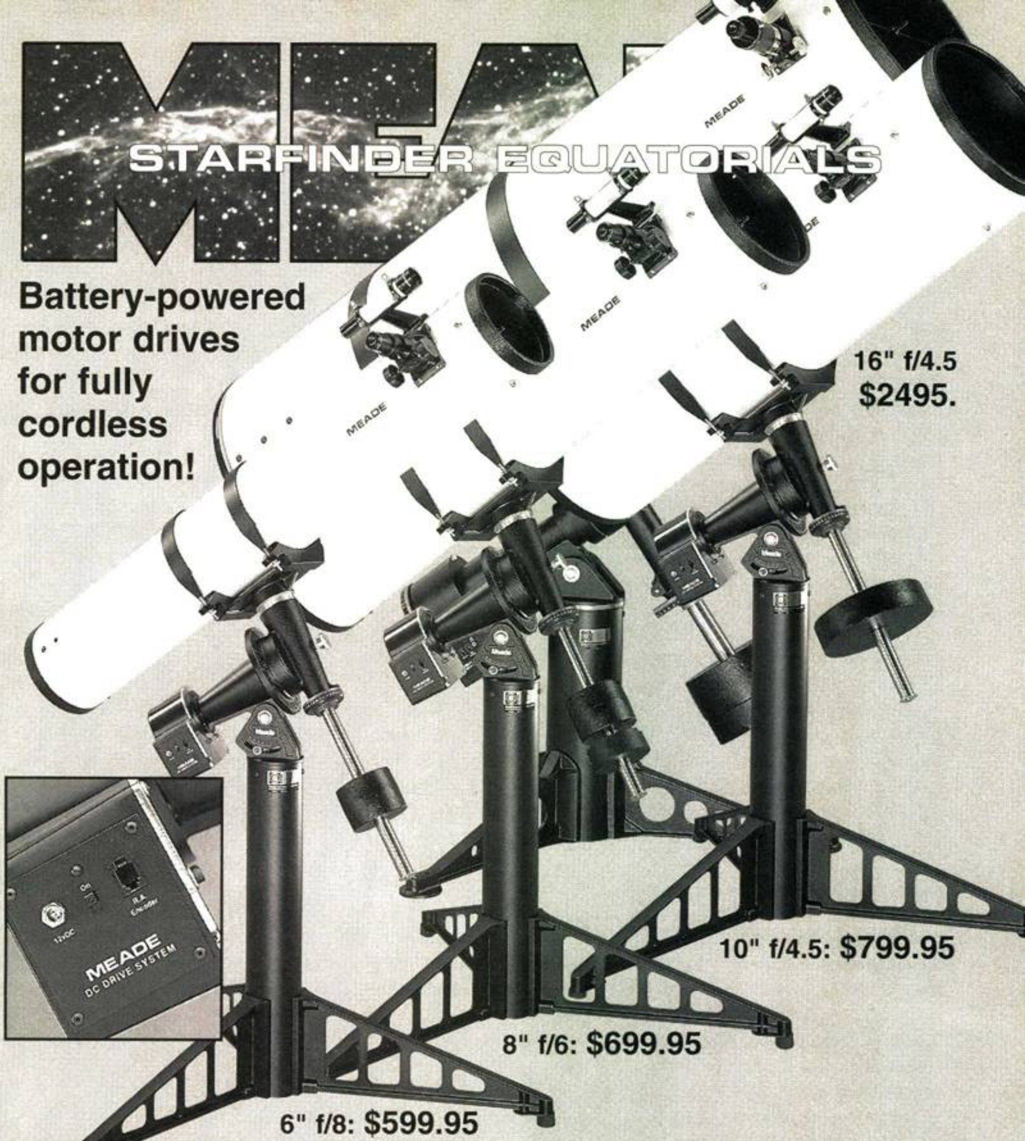

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LETTERS

Choosing a Camera for Sky Shots

I enjoyed Michael Covington's article on selecting astrophotographic cameras (March 1996). If you already own an automatic-everything camera for normal photography, as I did, there's another good reason to choose a manual camera: buying the manual body lets you shoot two types of film and/or lenses for standard daytime photography.

Before getting into sky shooting, I owned a Canon AE-1 and a selection of Canon lenses. I found a Canon FT-b QL, which has a mechanically timed shutter and uses a battery only for light meter, and can use the same lenses on both cameras. Now, during the day, I can shoot two types of film, two lenses, or different exposures simply by switching cameras. And I'm never without a camera when one needs cleaning. — *Timothy Miller, St. Charles, Missouri*

After reading this excellent article, I was alarmed by Covington's assertion that an Olympus OM-1 would be damaged by alkaline batteries. I checked with Olympus service centers and camera shops, who thought alkaline batteries would not damage the camera, but they would produce light meter readings inaccurate by as many as three stops.

The best solution is to use the new zinc-air batteries. I recently paid $8 for one in Dallas. They last for about 8 to 10 months. Or one could have the meter altered to accept alkaline batteries, a more expensive proposition. The new zinc-air batteries will also supplant the now phased-out mercury cells in other cameras such as the Canon F1 and the Leica M5. — *Jim Williamson, Dallas, Texas*

A Foggy Clarification

John Shibley's "Beat Back the Dew Blues" (February 1996) made some good points about a soggy subject. But something he wrote ought to be corrected: "when the air temperature reaches dewpoint, water molecules slow down to the point where you've got dew on your eyepieces, camera lenses, the telescope. . . ." When the air temperature reaches the dew point, you have fog, not dew. Dew forms when the temperature of exposed objects falls to or below the dew point temperature of the surrounding air. — *Ron Thorkildson, Aloha, Oregon*

— John Shibley responds: Most books on meteorology define dew point as the temperature at which moisture condenses out of the air. Fog depends more on "condensation nuclei," tiny particles of dust or smoke around which moisture can condense and remain airborne.

Real Life: Don't Interfere with Astronomy, Please

Ray Grasshoff's Forum piece, "Enjoying Astronomy Despite Everything Else" (November 1995), echoed my own story. Indeed, a full and challenging life often douses the flames of astronomical interest, but not the embers. I find that networking with others keeps you plugged in and excited.

After starting The Spyglass Network, an active group of astro networkers, I realized I'm having more fun now than I did during my years of active observing. To join us, write me. — *Gary Likert, 1203 Highway 25, Gallatin, Tennessee 37066*

Landolfi Revisionism

It was quite thrilling to see my article "Come-as-You-Are Astrophotography" (February 1996). However, some errors should be corrected. One of the pictures is described as being taken over the Long Island Sound, whereas it was made at the Great South Bay. The "patriotic moonrise" was taken in Farmingville, not Farmingdale, New York. You had me shooting nearly every shot on Ektachrome 200, a film I never have used — everything was taken on Elite 100 slide film. — *Larry Landolfi, East Islip, New York*

It's important in solar observing not only to warn people properly about the dangers of viewing but also not to give incorrect warnings. Claiming that something is dangerous when it isn't can lead readers not to trust correct information.

Such an incorrect warning appears in Landolfi's article. In both a figure caption and the text below it, the author describes how to make a solar filter by using two layers of completely fogged and processed T-Max 100 film. Most black-and-white films, when properly processed, make good neutral density filters and are safe for the eye. So the warning "never look through the filter toward the Sun" is not proper. As long as the "Sun-dot filter" is made of fogged and processed black-and-white film with standard silver content, his warning is not valid. — *Jay M. Pasachoff, Williams College, Williamstown, Massachusetts*

— John Shibley responds: Newer T-Max black-and-white emulsions have significantly less silver content than older black-and-white films like Tri-X and Plus-X. And since it's the silver that blocks sunlight in the Sun Dot photographic filter, prudence dictates you should only use it as such. When it comes to observing the Sun, err on the side of safety and use filters certified safe for visual work.

Speaker Is Not Against CCDs

"CCDs Front and Center" (Amateur News, April 1996) contains significant errors about a talk I gave to an imaging conference last October. The story mischaracterizes me as making a "broad indictment" of CCDs, an assertion I did not make.

I've worked with CCDs at the Jet Propulsion Laboratory for more than 10 years, and would not put them down or cast their devotees in an unfavorable light. — *Brad Wallis, Thousand Oaks, California*

Correction

The photograph of Comet de Vico on the cover of the February 1996 issue was taken by James R. Foster. ☐

ASTRONOMY welcomes feedback. Send it to ASTRONOMY Letters, P.O. Box 1612, Waukesha, WI 53187, or on the Internet use letters@astronomy.com. Letters may be edited for space and clarity.

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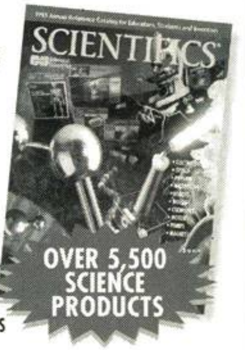

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Astronomy's Strange Trip

by Linda Zimmermann

Humans are the only known creatures in the universe able to grasp the nature of the cosmos. Thanks to our unique powers of reasoning, we have traveled through the ages to accumulate a battery of sound astronomical theories.

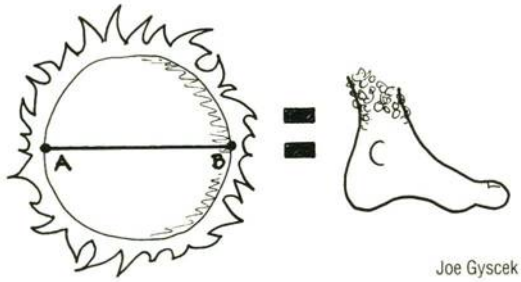
But the road to higher levels of understanding wasn't always straight. Along the way long, circuitous detours carried many a thinker far and wide through a wilderness of what we would today call, for lack of a better word, "bad" astronomy.

Picture the late-afternoon Sun hanging over the Greek seaport of Ephesus in the 6th century B.C. After a hard day of thinking, the philosopher-scientist Herakleitus reclines in his favorite chair and rests his feet atop a short marble column. He has been pondering the diameter of the Sun for some time and as it moves toward the horizon, it appears to touch his outstretched foot. As he compares the length of his extremity with the size of the object in the sky, the answer suddenly becomes clear. Herakleitus' remarkable conclusion from this observation? The diameter of the Sun is the length of a human foot.

Regardless of the Greeks' beliefs, it was generally accepted that the Sun, Moon, planets and field of stars were affixed to their own solid, crystalline sphere. As these spheres rotated, the bodies moved along their paths through the sky. This was an elegant theory that appealed to the sensibilities of the Greeks of the day, so elegant that many were willing to overlook the fact that the theory failed to explain observed planetary motion.

Eudoxus of Cnidus was not willing to overlook that fact; he went on to put the crystalline sphere theory to the test with actual observations. Convinced that the prevailing theory of spheres was incorrect, he boldly flew in the face of convention. Rather than abandon the erroneous spheres, Eudoxus added more spheres. A lot more.

His so-called "Spheres of Eudoxus" consisted of 27 nesting, rotating spheres. Each of the planets had four spheres in his scheme of the universe, while the Moon only required three spheres. Many of Eudoxus' contemporaries were willing to overlook the fact that 27 spheres failed to explain obvious things like eclipses and the orbit of Mars. As centuries passed, these errors became more obvious and more numerous. By the time the 2nd century A.D. rolled around, the great mathematician Ptolemy realized that something must be done. Ptolemy's solution to the problem? In a prime example of Bad Astronomy, add more spheres. A lot more.



Joe Gyscek

Ptolemy reasoned that if 27 spheres were elegant, 80 were no less than divine. While the ensuing centuries would see several more variations on the theme, the basic Eudoxus/Ptolemy system persisted for another 1,500 years.

In the meantime, there would be the Dark Ages to contend with. Would-be scholars of that era turned to the father of tabloid science, Pliny the Elder. Born in 23 A.D., Pliny's only surviving work is his *Historia Naturalis*, a lengthy work composed of volumes of virtual nonsense.

Within the pages of his great monument to science, this tireless seeker of knowledge declares that the universe is essentially a confused mess, obeying no mathematical laws and completely beyond our ability to ever measure. And what did the mysteries of the Earth, stars and planets matter anyway, he continued; it was obvious that God had no interest in them,

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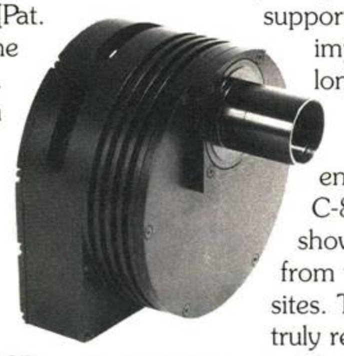

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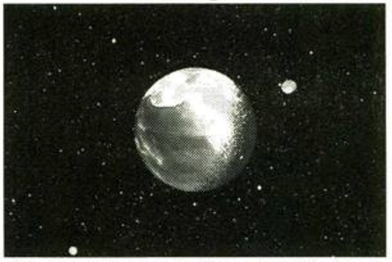

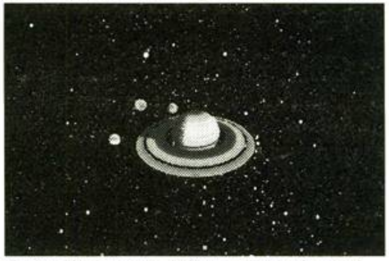

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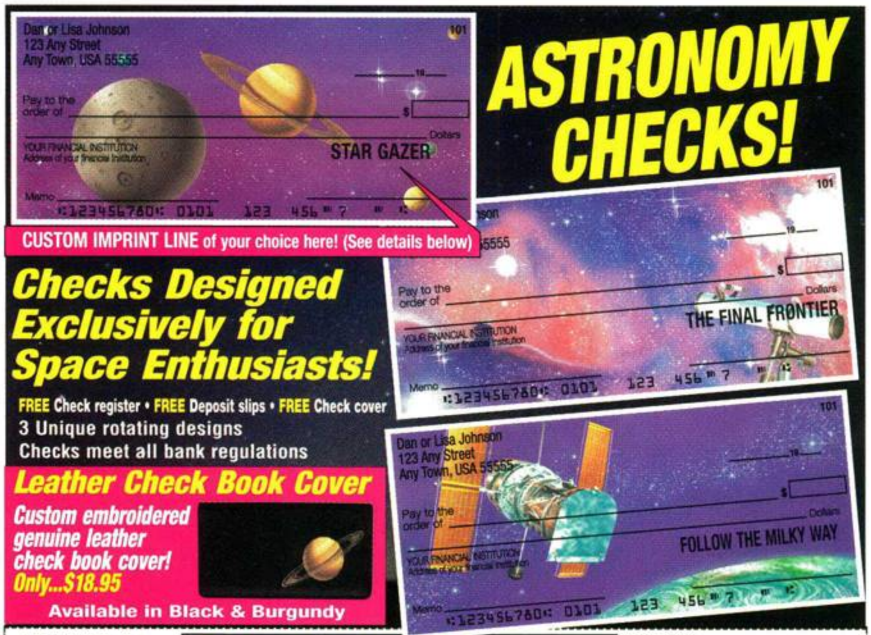

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Six hundred years after Pliny, people like the venerable Bede and Gregory of Tours were still mired in the ignorance of their predecessors; maintaining that heavenly bodies were of no real importance and still firmly believing in magic and omens.

Unfortunately, such ideas did not begin to face true critical scrutiny until the 12th century, when Western intellect began its slow emergence out of the quagmire of ignorance in which it had been content to sit for a thousand years. It would be up to men like Copernicus, Tycho, Galileo and Kepler to hoist the sails and chart a course out of superstition and into science. That course was not easy, however, as the journey to modern science was threatened by fear, greed and inquisitions.

Today, the Inquisition, at least, has gone away. Astronomers are now free to speak of the big bang, black holes, and dark matter, and technology has given them remarkable new eyes to look upon the universe. Within our lifetimes, it is possible that we may finally be able to understand this vast universe and answer its many riddles.

Regardless of how the big issues resolve themselves, we should remain confident that if there are answers to the universe which the human mind can comprehend, they will eventually be found. In some ways our self-correcting journey of discovery, bad astronomy and all, has borne itself out. Knowing what promise lies ahead, who would've wanted to take this trip any other way? □

Linda Zimmermann is a freelance science writer living in Manuet, NY. Her book Bad Astronomy is available for $19.95 from Eagle Press, P.O. Box 487, Piermont, NY 10968.

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ASTRO NEWS

Primeval Galaxies at Last

Astronomers are finally spotting the long sought-after progenitors of modern-day elliptical and spiral galaxies. A group led by Chuck Steidel of Caltech has turned up 23 primeval galaxies at least 10 billion light-years away. The large number of galaxies at such enormous distances implies that galaxies were forming in surprisingly large numbers at a time when the universe was only 10 or 20 percent of its current age.

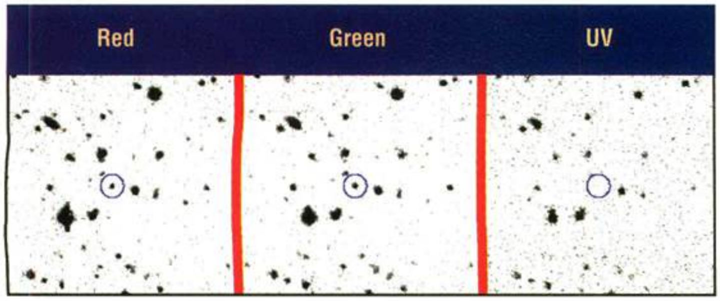
Steidel's team employed a clever new technique for finding primeval normal galaxies. Using four different telescopes, the team took a series of deep images of the sky through red, green, and ultraviolet filters.

Young galaxies radiate strongly in the blue and ultraviolet because that's the dominant emission of their young, hot stars. But ultraviolet radiation from extremely distant galaxies doesn't make it all the way to Earth because it is absorbed en route by hydrogen atoms. Steidel's team used a computer to look for galaxies that showed up in red and green light, but not in ultraviolet.

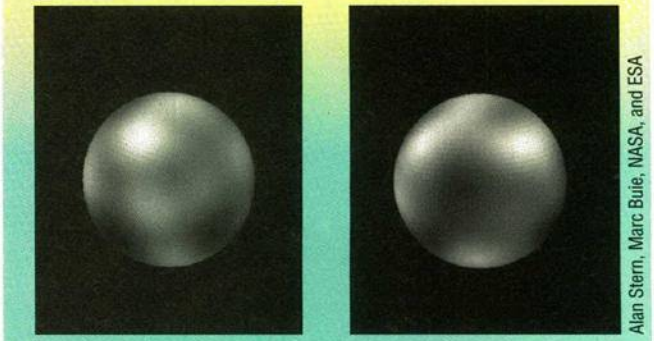
To determine the distance to the 24th- and 25th-magnitude galaxies, Steidel's team took their spectra with the 10-meter Keck Telescope in Hawaii, the world's largest telescope. Based on the redshift of the galaxies' light, Steidel could tell they are far beyond any normal galaxies previously seen.

Despite their great distances, however, the galaxies are as massive as those like the Milky Way. "The objects we are seeing are probably the predecessors of today's bright galaxies, seen at a point shortly after they first came together," says Steidel.

A PRIMEVAL GALAXY at least 10 billion light-years away indicates what the Milky Way looked like right after its birth. The galaxy shows up in red and green light, but its ultraviolet light doesn't make it all the way to Earth.



Chuck Steidel, Caltech



Alan Stern, Marc Buie, NASA, and ESA

THE FACE OF PLUTO. The never-before-seen surface of the most distant planet is visible in these images made from Hubble Space Telescope data taken in 1994. The images form a global map of bright and dark features that may be basins or fresh impact craters. Most likely the bright polar caps and other bright areas result from frosts and chemicals from Pluto's atmosphere.

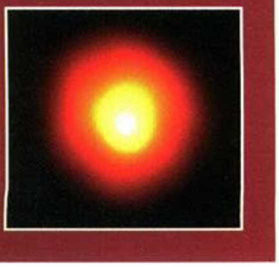
Core of Great Attractor Found

In 1986 a team of astronomers announced that the Milky Way Galaxy, along with a 200 million light-year slice of the local universe, was taking a 1.2 million mph joy ride toward the constellations Hydra and Centaurus (see "Cosmic Tug of War," July 1993). The only explanation for this bulk flow motion was that some enormous concentration of mass, dubbed the Great Attractor, was pulling the local universe toward it.

Astronomers have seen the massive supercluster of galaxies 300 million light-years away that is responsible for this motion. But strangely, they hadn't found a truly massive cluster like the great Coma Cluster, of the type normally found in such massive superclusters.

But finally, a decade later, an international team

THE FIRST DIRECT IMAGE OF A STAR other than the Sun shows the face of Betelgeuse, the second brightest star in Orion. Astronomers Andrea Dupree and Ronald Gilliland used the Hubble Space Telescope to produce the image, which suggests that powerful, unknown phenomena may affect the surfaces and atmospheres of some stars. The disk of Betelgeuse shows a huge hot spot while a tenuous outer atmosphere emits copious ultraviolet radiation. The hot spot is at least 2,000 kelvins hotter than the surface of the star.



Andrea Dupree, Ronald Gilliland, NASA, and ESA

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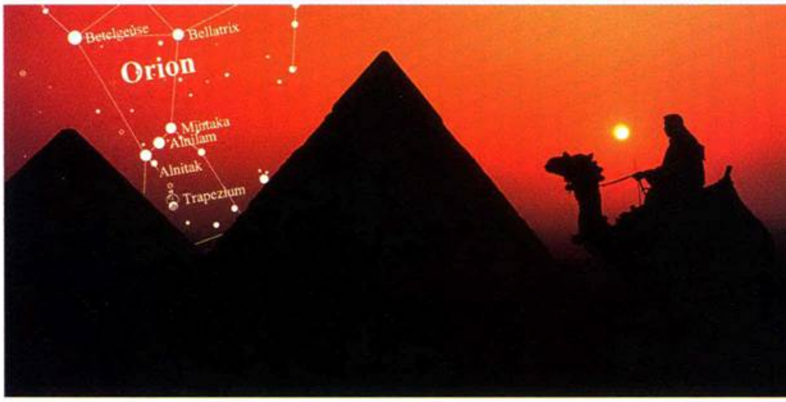

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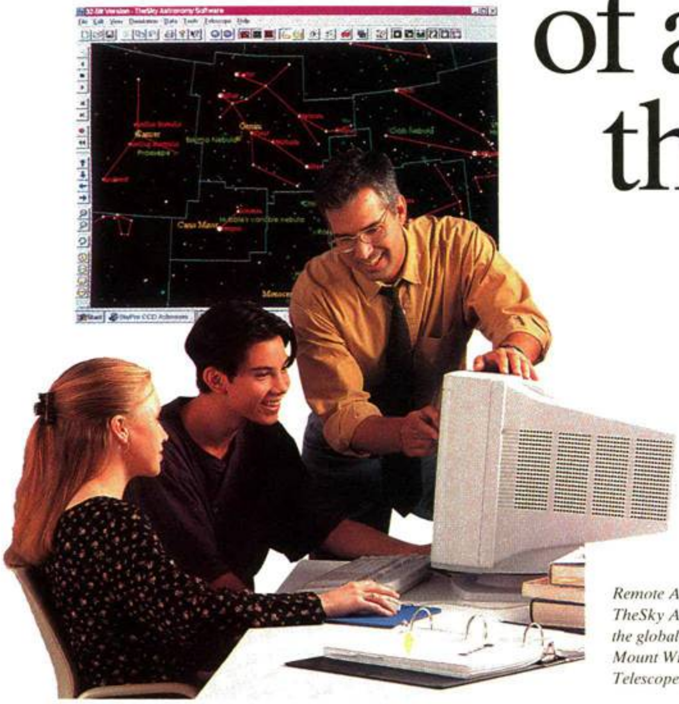

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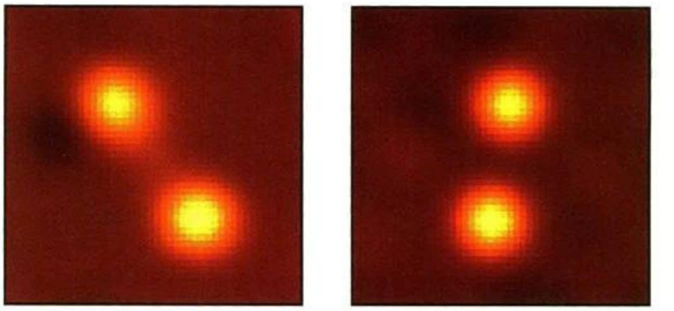
of astronomers appears to have finally identified the massive galaxy cluster at the core of the Great Attractor supercluster. In the February 8, 1996 *Nature*, Renee Kraan-Korteweg of the Observatoire de Paris and colleagues report that a rich cluster called Abell 3627 lies at the Great Attractor's core.

Astronomers have known about the cluster for years, but it is largely obscured by dust in the Milky Way's disk. Kraan-Korteweg's group took deeper images through the Milky Way. By subtracting out the effects of dust obscuration, they were able to reveal over 100 new galaxies. The motions of the galaxies in Abell 3627 indicate that this cluster is much more massive than previously believed, equal to that of the Coma Cluster.

Sharper Than Hubble

After astronauts installed corrective optics on the Hubble Space Telescope in December 1993, one astronomer declared, "It's as close to perfection as engineering can achieve and the laws of physics will allow." True, but even Hubble's ultrasharp resolution is limited by the fact it has just one primary mirror 2.4 meters in diameter.

Radio astronomers have long employed a technique called interferometry to get around this limitation. By spacing two or more radio telescopes far apart, they can achieve the resolution of a telescope as large as the separation between the telescopes. A team from the University of Cambridge in England has successfully applied this technique to optical telescopes, with an interferometer called COAST. Using just three 16-inch telescopes spaced six meters apart, they have taken images of Capella from the ground that are several times sharper than those possible with Hubble.


University of Cambridge

SURPASSING HUBBLE from the ground, these images, taken two weeks apart by the COAST interferometer, show the motion of Capella's two stars during their 104-day orbit.

The images are the first to resolve Capella into its two constituent stars. The binary is about 40 light-years away and the two components are separated by only three-fourths the Earth-Sun distance. From Earth, they are a minuscule .05" apart, the width of a penny at 50 miles. By spacing four telescopes 100 meters apart, COAST should resolve details only .001" across.

Team-leader John Baldwin thinks COAST's successors might be able to image Earth-sized planets orbiting nearby stars and take high-resolution images of swirling material just outside a black hole. "I believe that this type of telescope will be an essential feature of much optical astronomy in the next century," he says.

To download images and information, check out http://www.phy.cam.ac.uk/www/research/ra/coast.home.html.

Comets Falling into Young Star?

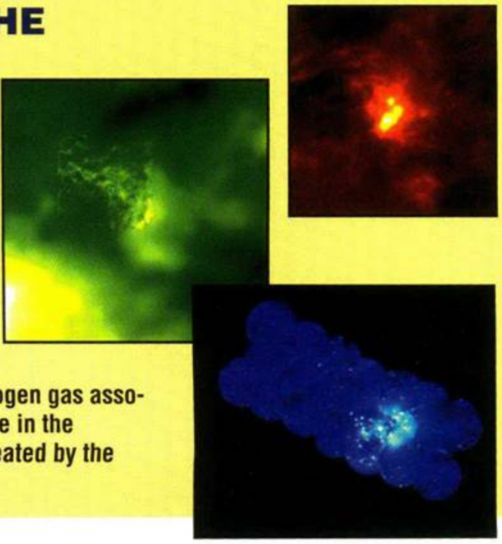
Comets may be falling into a young star in Sagittarius, say astronomers Carol Grady and Mario Pérez of the Applied Research Corporation and Karen Bjorkman of the University of Wisconsin. They reported their finding at the San Antonio meeting of the American Astronomical Society in January 1996.

Observations with the International Ultraviolet Explorer satellite and the Astro-2 shuttle payload detected unexpectedly large amounts of gas moving toward the hot young star HD 163296. This star, which lies about 550 light-years away and appears to be still contracting toward the main sequence, is likely only a few million years old. Previous observations had uncovered gas flowing outward from it in a dense and highly vari-

GETTING TO KNOW THE PLEIADES

Astronomers Steven Gibson, Kenneth Nordsieck, and Mark Holdaway are studying the Pleiades star cluster in unprecedented detail by observing it in multiple wavelengths.

The blue image shows the group in visible light, revealing faint reflection nebulosity created by starlight reflecting off dust grains. The green image shows radio wavelength emission that reveals wisps and streamers of atomic hydrogen gas associated with the dust filaments. The red image in the infrared unveils glowing filaments of dust heated by the brighter Pleiades stars.


Steven Gibson and Kenneth Nordsieck (Univ. of Wisconsin), and Mark Holdaway (NRAO)

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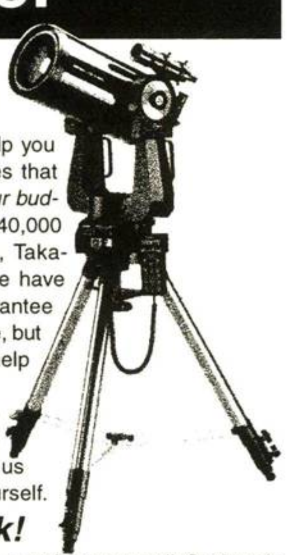

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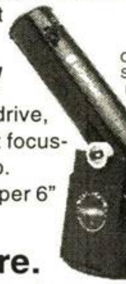

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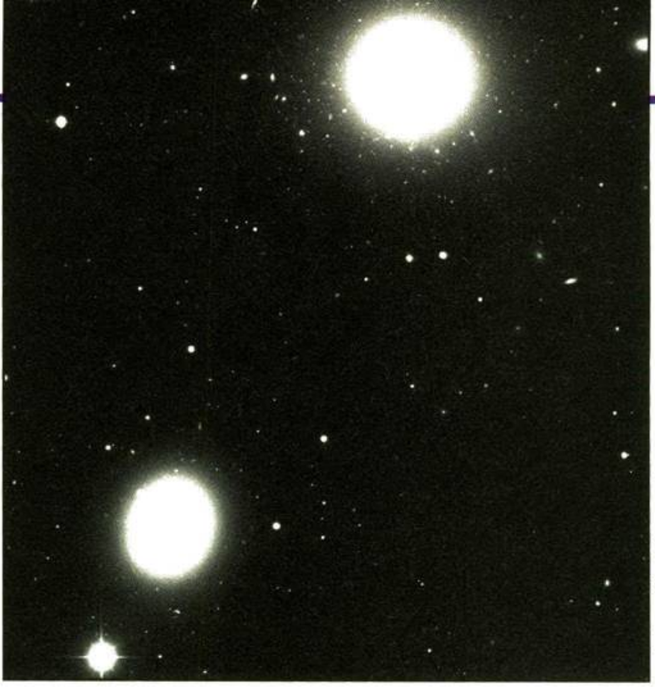
able stellar "wind." The new observations, however, found evidence of atomic carbon, iron, silicon, aluminum, and magnesium falling toward the star.

The atomic magnesium was especially indicative. This substance cannot exist for more than a few seconds in the intense radiation field of the hot star. Its likeliest source is solid dust grains typical of those found in comets. The astronomers propose that the best explanation is that infalling comets carry the magnesium (and other elements) in close to the star before their ices evaporate and the solid dust grains vaporize.

The process is probably common, say the astronomers. Previous observations, not understood at the time, lead them to think that in the line of sight to HD 163296, something like 35 comets may disappear into the star each year. It suggests that the star may be developing a disk like that around Beta Pictoris, and further that proto-planetary material may surround massive stars like HD 163296.



Anglo-Australian Telescope Board

A MAGNET FOR DARK MATTER: The giant elliptical galaxy NGC 1399 in the Fornax Cluster lies at the top of this photo. Other dark matter congregates around the entire cluster.

Dark Matter Hierarchy

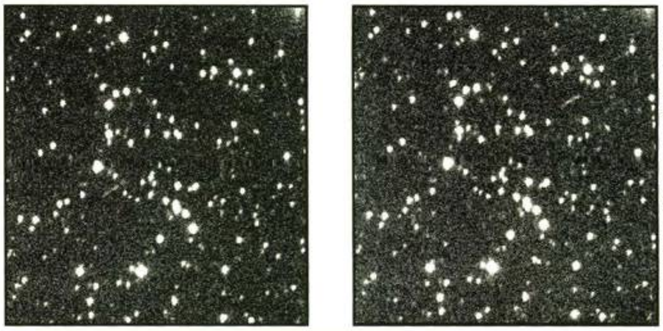
Recent observations of the Fornax galaxy cluster from the Japanese X-ray satellite ASCA reveal that dark matter — the strange, invisible stuff that comprises about 90 percent of the universe's mass — clumps together on at least two distinct scales. Some of the dark matter congregates around the entire cluster, while the rest clings to the giant elliptical galaxy at the cluster's core, NGC 1399. The finding suggests that dark matter either exists in at least two different forms, or clumps together in hierarchical structures, just as visible matter clumps together in galaxies, clusters, and superclusters.

Because dark matter by its very nature is invisible and thus hard to detect directly, the research team, led by Yasushi Ikebe of the University of Tokyo, had to look for it indirectly. They measured the distribution of hot, X-ray emitting gas in the cluster. Regions containing an above-average density of dark matter should attract more gas, so the hot gas should act as a tracer for dark matter.

The ASCA results, reported in the February 1, 1996 *Nature*, allow cosmologists to breathe a sigh of relief. The fact that dark matter exists in clumps supports the popular notion that galaxies and larger structures formed from small clumps of dark matter. The Japanese team further speculates that perhaps dark matter takes two distinct forms, which would dovetail nicely with cosmology scenarios involving a mix of fast-moving "hot dark matter" and slower-moving "cold dark matter." These scenarios do the best job of explaining how a lumpy universe evolved from an apparently smooth beginning.

The Milky Way's Feeding Frenzy, part 2

The Milky Way's closest galactic neighbor, the Sagittarius Dwarf Galaxy discovered just two years ago, is much bigger than astronomers had thought. Christophe Alard of the Observatoire de Paris and a group led by Mario Mateo of the University of Michigan report in the February 10, 1996 *Astrophysical Journal Letters* that the galaxy stretches across 26,000 light-years of space, making the dwarf almost three times wider than previous estimates.



Robert Jedicke, Spacewatch/Univ. of Ariz.

AN ASTEROID-BOUND EXPLORER COASTS away from Earth in these two CCD images taken by the Spacewatch asteroid-detection telescope on Kitt Peak in Southern Arizona. Pictures of NEAR (Near Earth Asteroid Rendezvous) were taken on February 18 between 12:12 and 12:45 UT, less than 16 hours after the spacecraft lifted off on a Delta rocket from Cape Canaveral, Florida. Next up for NEAR is a June 1997 flyby of asteroid Mathilde, followed by its return to Earth in January 1998 for a gravitational slingshot to the probe's final destination, a one-year orbital study of asteroid Eros that begins in February 1999. (See "Far Journey to a NEAR Asteroid," March 1996.)

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Because it is only 90,000 light-years from Earth, the galaxy extends across 17° of sky, which would equal the width of 34 Full Moons. The galaxy with the second largest angular width, the Large Magellanic Cloud, covers about 10°.

Mateo's group discovered the true size of this dwarf galaxy by detecting three 18th-magnitude variable stars near the globular cluster M55, which is a full 10° from the center of the dwarf. They determined that the variable stars were the same distance from Earth as the dwarf galaxy. Stars near the variables had the same age and abundance of heavy elements as stars in the Sagittarius dwarf, indicating that they too belonged to the mini-galaxy.

The highly elongated shape of this dwarf supports the view that it is a former satellite galaxy that is now being shredded by the Milky Way's immense gravity (see "The Milky Way's Feeding Frenzy," AstroNews, December 1995). Mateo's group is next going to find out if the Milky Way's halo is made up of lots of remnant dwarfs. "If this is true, we would expect the halo to be like a big bowl of spaghetti, with each strand corresponding to a different disrupted satellite," says Mateo.

A Record-Breaking Galaxy

As sports fans know, records in track and field continually fall by the wayside. The same thing happens in astronomy, particularly with the record for most distant galaxy. The newest title-holder is a faint, unnamed galaxy roughly 14 billion light-years from Earth, meaning astronomers are seeing it as it existed a mere one billion years after the big bang.

A team of four Caltech astronomers discovered the galaxy with the 10-meter Keck Telescope in Hawaii, which itself is the record-holder for the world's largest telescope. The team, led by Limin Lu, didn't actually "see" the galaxy. Instead, they detected the galaxy by noticing how it absorbs light from a more distant quasar, leaving dark gaps in the quasar's spectrum called absorption lines. They determined the galaxy's distance by how much the absorption lines are shifted toward the red due to the expansion of the universe. Lu's team did, however, detect a faint blob near the quasar that might be the actual galaxy.

The Caltech team has indications that the galaxy is rotating at a high speed, meaning it could be a young spiral containing roughly the same mass as the Milky Way. "If the galaxy is indeed massive and rotating, then it may very well present a problem for cosmology," says Lu, noting that current cosmological theories have a hard time explaining how large galaxies formed so soon after the big bang. "But it is premature to say if our observation poses a real problem because our conclusion is not terribly secure."

EVENT HORIZON

A Martian Chronicle Etched in Stone

Unlike other Martian meteorites that have been dated to 1.3 billion years, the one cataloged as Allan Hills 84001 is very old indeed. Based on argon isotope dating, a team of British scientists derive an age of 4 billion years. This age supports the idea that Mars, along with the rest of the solar system, underwent a period of widespread heavy bombardment between 3.9 and 4.1 billion years ago. Further details may be found in the March 7, 1996, issue of *Nature*.

Quarkettes?

Sometimes it's the little things that matter. Physicists using the high-energy Tevatron particle accelerator at the Fermi National Accelerator Laboratory found this out after hurling positively charged alpha particles into gold foil. The 1.8-trillion-electron-volt Tevatron allowed researchers to explore matter to unprecedented scales — about one ten-thousandth the size of a proton. The particle-tracking charts revealed more high-angle splatters spewing forth from quark collisions than can be accounted for by the standard model of the fundamental structure of matter. This suggests that quarks themselves may have some internal structure. Results appear in the February 9, 1996, issue of *Science*.

Pluto Discoverer Turns 90

Clyde Tombaugh, the only living discoverer of a main planet in the solar system, turned 90 last February 4. To celebrate, New Mexico State University, where Tombaugh is a professor emeritus, held a luncheon in his honor. Present along with his many friends and colleagues was Rob Staehle of the Jet Propulsion Laboratory. Staehle is project manager for NASA's proposed Pluto Express mission, a planned flyby of that remote world. Staehle had phoned Tombaugh earlier asking permission to visit his planet. Tombaugh called the mission "terrific."

NMSU photo by Dennis Daily

Clyde Tombaugh with Rob Staehle of NASA's Pluto Express project.

Comet Hale-Bopp Is a Gas, Gas, Gas

When Comet Hale-Bopp (1995 O_1) was discovered over a billion kilometers from the Sun. Being that far from the Sun, Comet H-B should have been too cold to be active. But a team of astronomers from France and Spain now report that the outflow of carbon monoxide gas is what is driving dust grains away from the comet's nucleus. More outgassing means more dust and a brighter comet.

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The R.A. and DEC assemblies incorporate two thrust bearings each. These axes are preloaded for zero play and variable friction clutched by a single knob. The 3½" diameter laser engraved precision setting circles are readable to ¼ degree in DEC and four minutes in R.A. The R.A. circle is direct reading indexed to the R.A. gear motion. All these technical features deliver the smoothness, refinement, controllability and precision that you've always wanted in a fine mount.

The CG-9¼ dual axis DC electronics are state-of-the-art. Four tracking rates are available: sidereal, King, lunar and solar. It has four setting rates of 4x, 8x, 16x and 32x. Also it has three photo guide rates of ±30%, ±50% and 2x. The electronics have full feature PEC (Periodic Error Correction) built-in. TVC (Time Variable Constant) built-in is a user programmable declination backlash compensation for instantaneous tracking response. *Sky & Telescope* said, "the drive is so accurate that tracking was superb whether or not the electronic PEC feature was switched on."

The equatorial head weighs 21 lbs. without counterweight bar and is the heaviest individual component of this portable telescope. Total weight is 53 lbs.

The mount has an optional polar alignment scope available which works in both hemispheres. The latitude range is 0° to 64°.

With the addition of the optional Advanced Astro Master®, you have a computerized telescope.

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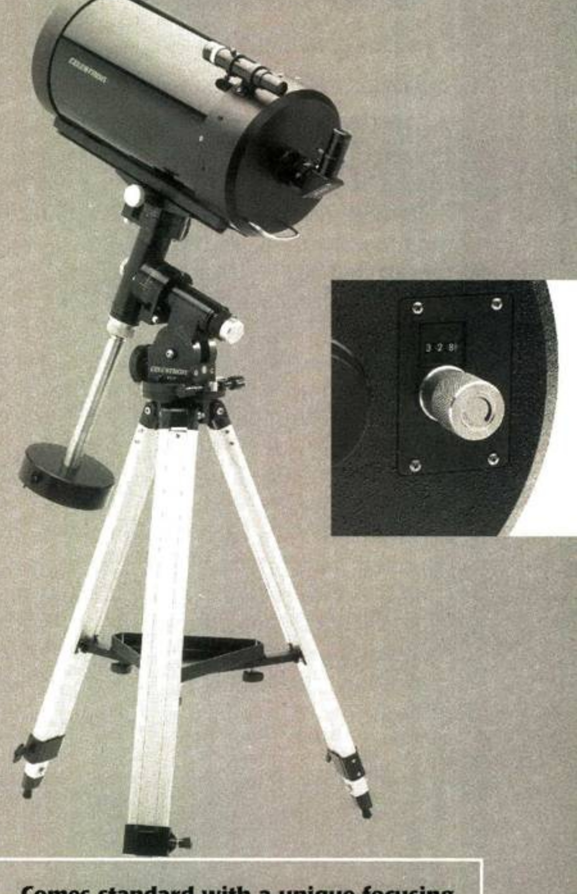

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It has a larger and heavier duty equatorial head than the CG-9¼. Both axes are driven by a 5.6" diameter, 360-tooth worm gear.

Electronics are similar to the CG-9¼.

The equatorial head weighs 31 lbs. and is the heaviest individual component of this portable telescope. Range 12° to 64°.

The rugged aluminum adjustable height tripod has 3" diameter legs, is 48" long and weighs 20 lbs.

Standard accessories include a 7x50 Finderscope, Star Diagonal – 1¼", Visual Back – 1¼" and a multi-coated 26mm Plössl Eyepiece – 1¼" (108x).

CG-14 – A 14" (356mm) telescope. It has a focal length of 3910mm and a focal ratio of f/11.

The German equatorial mount is the same as supplied with the CG-11 telescope but with additional counterweights.

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Standard accessories include a 7x50 Finderscope, Star Diagonal – 2" (with a 1¼" adapter) and a 26mm multi-coated Plössl Eyepiece – 1¼" (150x).

GP-C8 – This 8" (203mm) f/10 telescope comes with the Great Polaris mount.

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Both axes have precision 144-tooth lapped worm gears for very smooth motion. The adjustable height, very rigid wood tripod has excellent vibration dampening characteristics and has a handy accessory tray.

The GP mount has a built-in illuminated polar alignment scope for fast polar alignment.

The optional Polaris drive controller – a dual-axis motor drive/drive controller – complements the GP-C8. Its advanced motor technology utilizes DC servo motors with remarkable high efficiency allowing the system to be powered by a tiny 9-volt alkaline battery that lasts more than 48 hours! A manual clutch assembly override is convenient to use.

With optional accessories, the GP-C8 easily converts to a computerized telescope.

Standard accessories include a 6x30 Finderscope, Star Diagonal – 1¼", Visual Back – 1¼", and a 26mm multi-coated Plössl Eyepiece – 1¼" (78x). Weight of the complete telescope is 45 lbs.

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Spirals Show Their Dusty Disposition

Just how is dust distributed in spiral galaxies? Researchers from the University of Alabama have an idea, thanks to a number of chance alignments between foreground spiral galaxies and galaxies that lie farther away.

Astronomers Raymond White and William Keel looked at how the spiral galaxies blocked or transmitted light from background galaxies. Their findings, presented at January's American Astronomical Society meeting, suggest that most dust resides in the spiral arms themselves, with space between the arms remaining relatively free of obscuring material.

This finding has ramifications for a number of issues, including how much dark matter lurks in spirals, the rate at which new stars form in spiral galaxies, and the detectability of distant quasars over billions of light-years of space. Uniformly dusty spirals would affect how infrared astronomers deduce the formation rate of new stars, detected only by the heat given off by their cocoon of obscuring dust. Dust in galaxies also squelches light from distant quasars, affecting how near astronomers can see to the big bang. And evenly distributed dust might throw off dark matter calculations based on a galaxy's mass and opacity to light.

Now that astronomers have a better handle on how dust is distributed throughout typical spiral galaxies, they can more confidently tweak statistical models that steer the study of each issue. □

University of Alabama

A GRACEFUL SILHOUETTE BETRAYS the dusty arms of this spiral galaxy. Astronomers from the University of Alabama imaged other similar alignments with background galaxies to deduce how dust is distributed throughout spiral galaxies.

AMATEUR NEWS

California's Quieter Star Party

You've probably heard of the Riverside Telescope Makers Conference that's held each Memorial Day weekend in the mountains above Los Angeles. But how many know of Riverside's quieter, more laid-back sibling that takes place in the heart of southeast California's Mojave Desert?

Last September 22 through 24 marked the third gathering of Nightfall, a star party sponsored by the organizers of RTMC. The weekend event attracted 150-plus people to the Palm Canyon Resort, a mixed motel and RV park near Borrego Springs, California. Planners booked the entire desert resort, which offered a paved RV parking lot with electrical outlets that was perfect to set up scopes on. Since the party scheduled no daytime programs, star partiers were free to stay out all night observing and then while away the day sleeping in their rooms or lying around the resort's pool.

At dusk, California amateur astronomer Wayne Johnson joined astronomy popularizer Hal Jandorf to highlight what would be visible in the sky each night. This was followed by a talk on Native American lore given by two local nature guides. Then it was time to get down to some observing. Observers amply used two full nights of clear, dark skies to eye a variety of fall galaxies before the constellations of winter rotated into view, chock full of open clusters and glowing nebulae. As a bonus, daytime clouds that kept temperatures in the low-100s during the day cleared at sunset, letting the air cool to short-sleeve conditions. All told, attendees soaked up 20-plus hours of deep-sky observing and photography under these ideal circumstances.

To receive information on next year's NightFall, contact Bob Stephens, Fox & Stephens CPAs, 9045 Haven Avenue, Suite 109, Rancho Cucamonga, CA 91730, phone (909) 948-2205. — *Rick Shaffer*

80mm f/6 BRANDON Apochromatic Refractor

Photo by Tony Hallas, taken with the 94mm f/7 BRANDON.

Recent conversation between **VERNONscope** owner Don Yeier and famed astrophotographer Tony Hallas:

Don – You remember taking that half-hour exposure of Orion with the 94mm f/7 BRANDON Apochromat?
Tony – Yes, sure do, Don. Right fine optics, that 94.
Don – Well, we're coming out with an 80mm f/6 Apo. How much time to get the same photo?
Tony – About 25 minutes would do it.
Don – That's all?
Tony – How much?
Don – How much what? Oh, the 80mm? $995.
Tony – I'd like to try one!
Don – Wow, that's great!
Tony – I'll send a photo. How about Hyakutake?
Don – Can't wait. Thanks, Tony.

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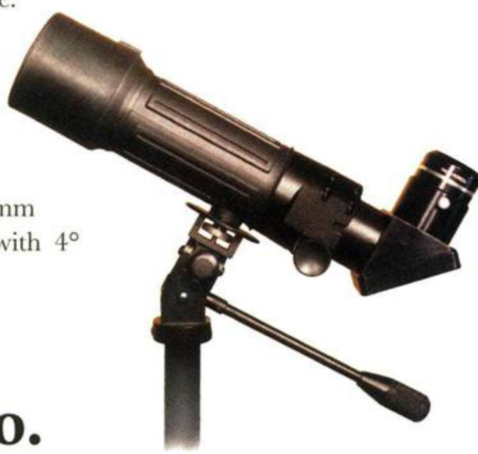

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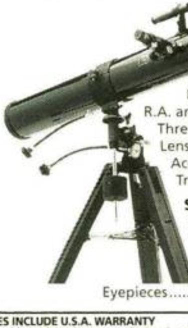

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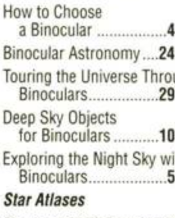

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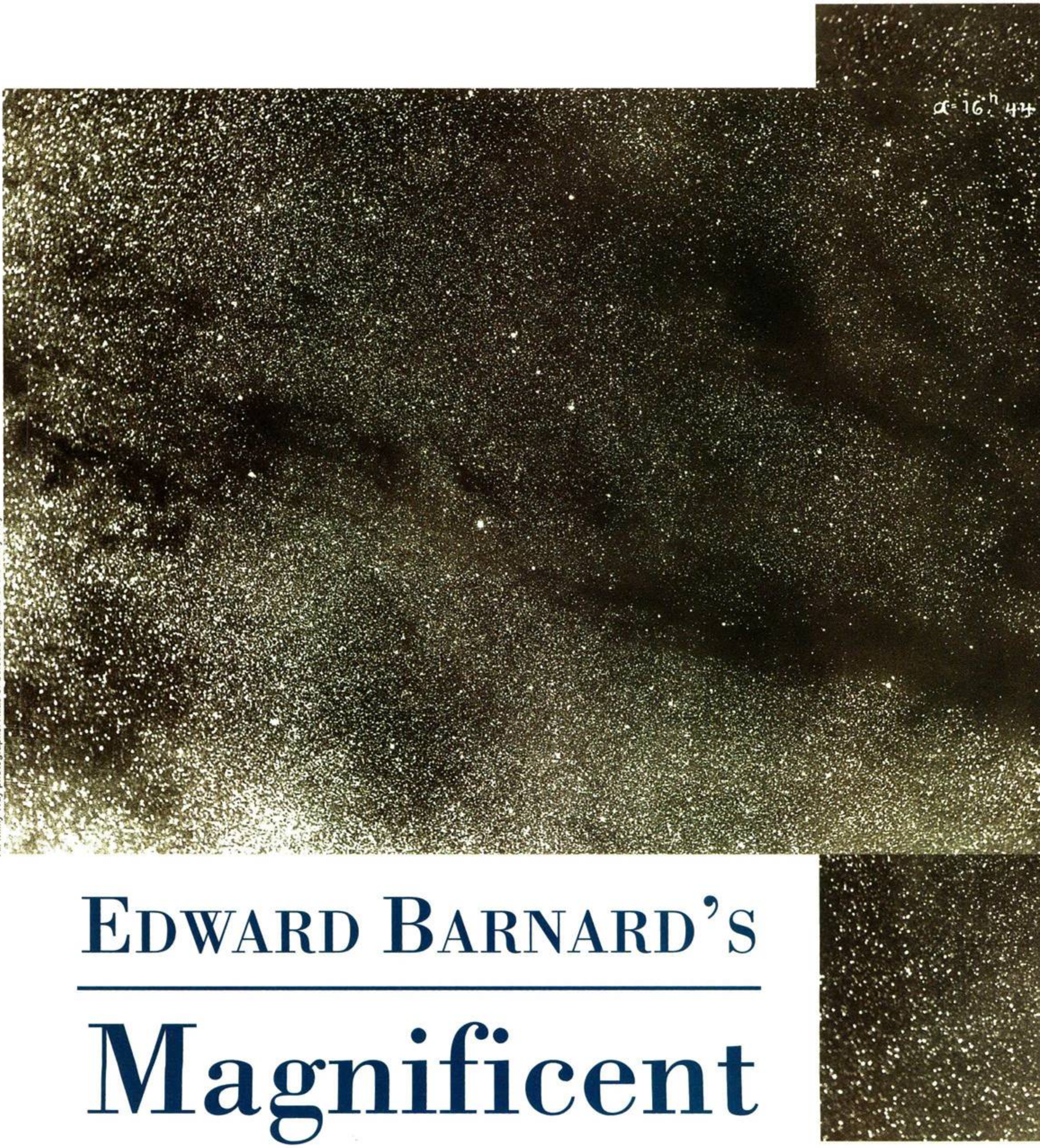
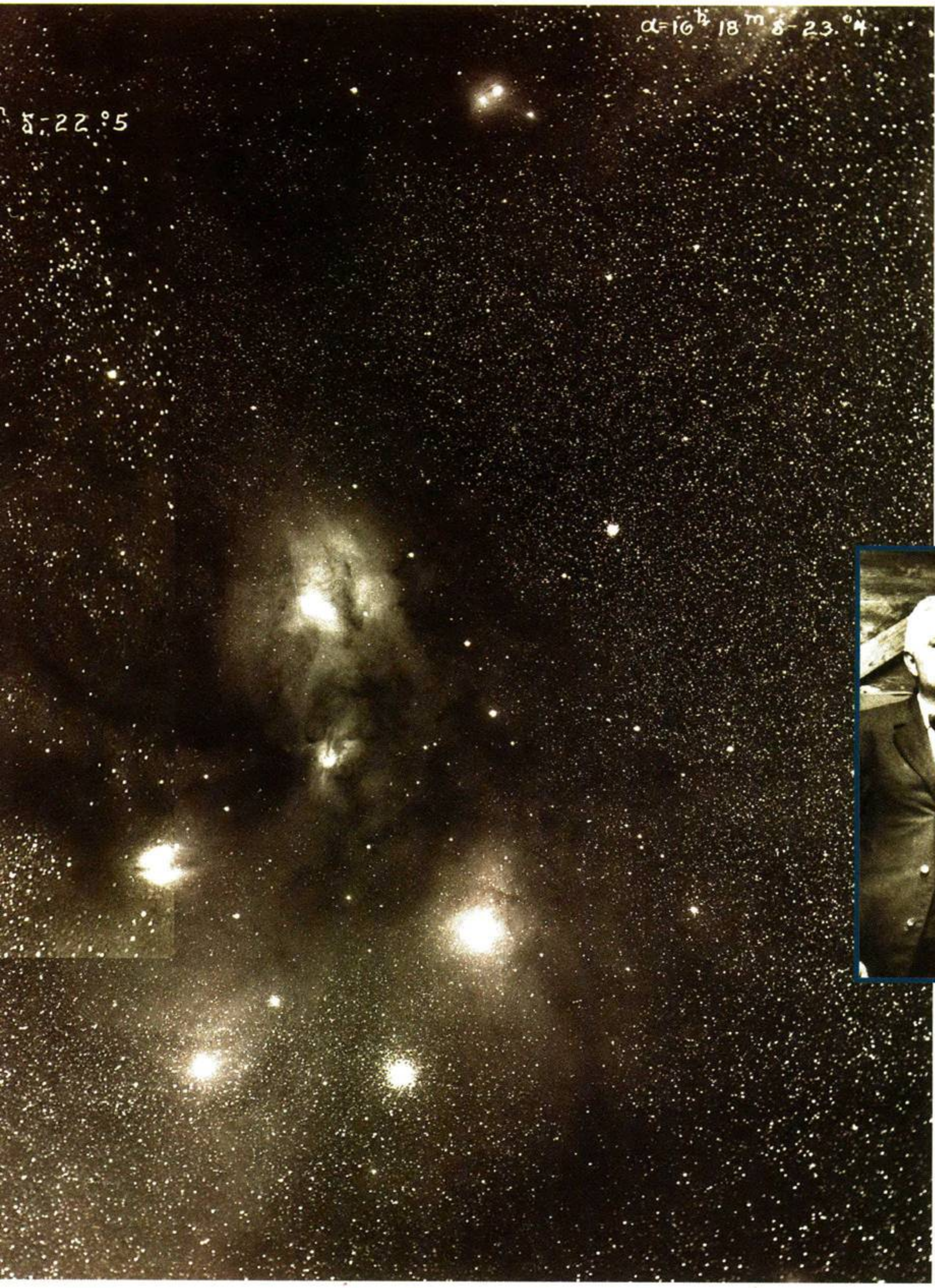


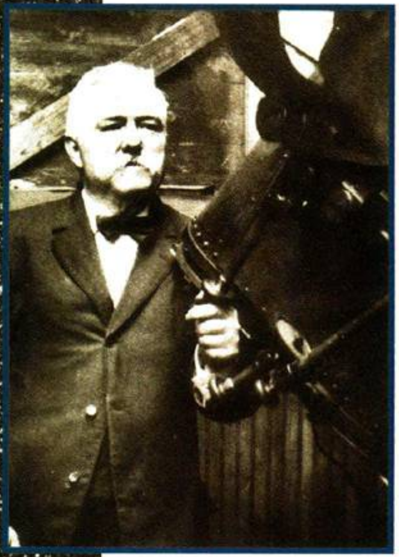
All Milky Way photographs: Atlas of Selected Regions of the Milky Way

EDWARD BARNARD'S

Magnificent Milky Way



"ONE OF THE MOST EXTRAORDINARY" regions in the sky, is how Barnard described this field around the 5th-magnitude star Rho Ophiuchi. It lies north of Antares, and contains, in addition to the Rho Ophiuchi Nebula itself (the bright mass just above and right of center), the globular clusters M4 and M80. All of these photos were taken on Mt. Wilson in 1905.



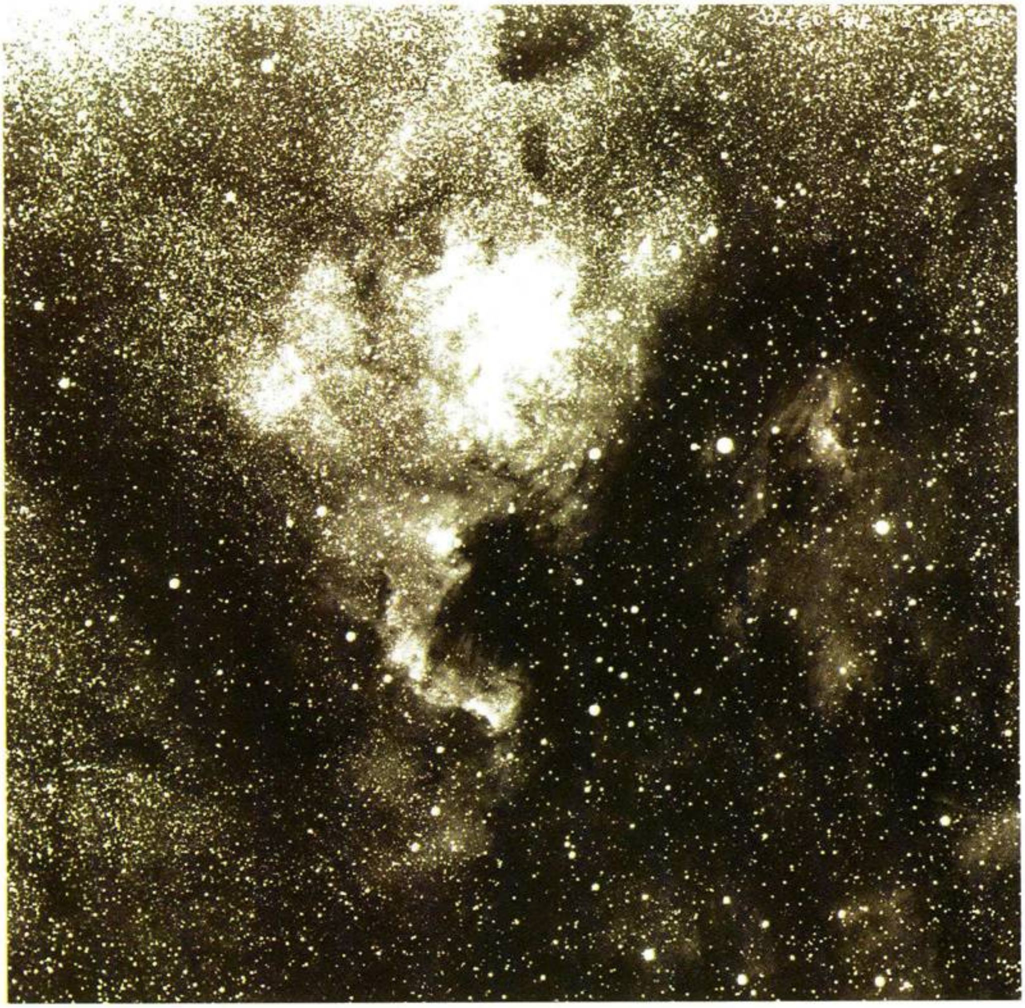
Yerkes Observatory

STILL DETERMINED at age 60, E. E. Barnard stands at the controls of his beloved Bruce Photographic Telescope.

The true grandeur of the Milky Way emerged when E. E. Barnard took its first photographic portrait.

by William Sheehan

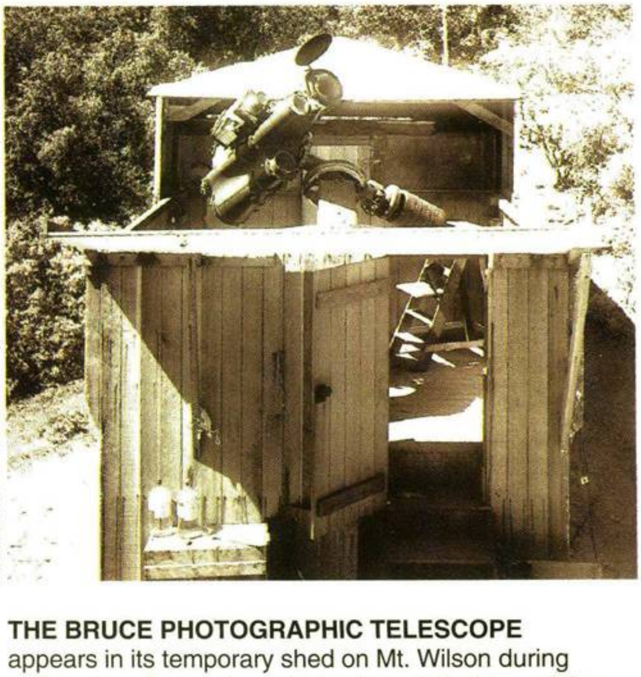
THE NORTH AMERICA NEBULA is one of the outstanding objects in the northern Milky Way. Barnard's rival, Max Wolf of Germany, first recorded this diffuse nebula, and he named it the "America" Nebula. Barnard was the first to refer to it as the North America Nebula, and so it has been called ever since. This was one of the last exposures Barnard obtained from Mt. Wilson.



As seen from a dark sky on clear June nights, the Milky Way is approaching its best; its ethereal river of light runs almost directly overhead, and allows careful scrutiny of its dark lanes, dim outliers, and overlying powdering of stars. But many of its wonders cannot be grasped by the eye alone. For this the photographic plate is needed, with its ability to accumulate an image over time.

The first successful wide-field photographs of the Milky Way were taken by Edward Emerson Barnard, one of the most versatile astronomers of the 19th century — perhaps the last to master the entire field of observational astronomy, and a marvelous visual and photographic observer as well. His plates recorded many of the Milky Way's most awesome structures: its great star-clouds and diffuse nebulae. To Barnard, the most wonderful of all its features were the "dark markings of the Milky Way." Their exact nature, however, long puzzled him. Were they "holes in the heavens," or were they vast clouds of dark material?

Barnard's odyssey began right after the Civil War. As a boy he endured a hardscrabble existence in his native Nashville, Tennessee, but he had a keen eye for visual observations, and he became an



Archives of Mt. Wilson Observatory, Huntington Library

THE BRUCE PHOTOGRAPHIC TELESCOPE appears in its temporary shed on Mt. Wilson during 1905, when Barnard used it to shoot 400 plates of the Milky Way.

expert photographer at a young age. By the 1880s, when he was in his early twenties, he was employed at a Nashville photographic studio during the day. At night he scoured the heavens for comets with a small telescope. "To me," he later recalled, "the views of the Milky Way were the most fascinating part of comet-seeking, and more than paid me for the many nights of unsuccessful work."

His success as a comet-seeker — he discovered ten between 1881 and 1887 — was what first catapulted him to fame and won him a position at the Lick Observatory on Mt. Hamilton, California. There he achieved even greater celebrity for his discovery of the faint fifth satellite of Jupiter, Amalthea, the last satellite to be discovered without photographic aid.

But his fascination with the Milky Way never left him. In 1889, during his first year on Mt. Hamilton, he began his pioneering work of photographing the Milky Way by strapping a wide-angle portrait lens (the 6-inch Willard lens) onto an equatorially mounted telescope and painstakingly guiding it for three hours on the stars of Sagittarius. By 1895, he had collected scores of these wide-angle plates, which revealed the Milky Way as never before.

Barnard had been a junior astronomer on the Lick staff for seven years, and had quarreled bitterly with the despotic Lick director, Edward Singleton Holden. To say that the two had a personality clash is to put it mildly (in his correspondence, Barnard used terms like "humbug" and "fake" to describe the director). At last he had had enough.

In October 1895, he left Lick and headed for the Yerkes Observatory, just then being organized on the shores of Lake Geneva, Wisconsin, by astronomical entrepreneur George Ellery Hale. Although Barnard desperately wanted to escape the misery of working under Holden, he agonized over the decision to leave California, and hoped to return one day.

Among his regrets on leaving Mt. Hamilton were not only the balmy weather and the seeing on that fortunately situated 4,212-foot peak, but the fact that he was leaving in the midst of unfinished work on the Milky Way.

In 1894, he described a plate exposed on this part of the sky to the English astronomer Arthur Ranyard: "It is essentially a region of vacancies. There is a great chasm here in the Milky Way." Another peculiar region was the one centered on Rho Ophiuchi, where a century before the great astronomer William Herschel had exclaimed to his sister Caroline, "Here surely is a hole in the heavens." Barnard, indeed, believed that vast chasms — holes in the sheets of stars — were registering on his plate. Ranyard, however, thought otherwise: "The dark vacant areas or channels . . . seem to me to be undoubtedly dark structures, or absorbing masses in space, which cut out the light from a nebulous or

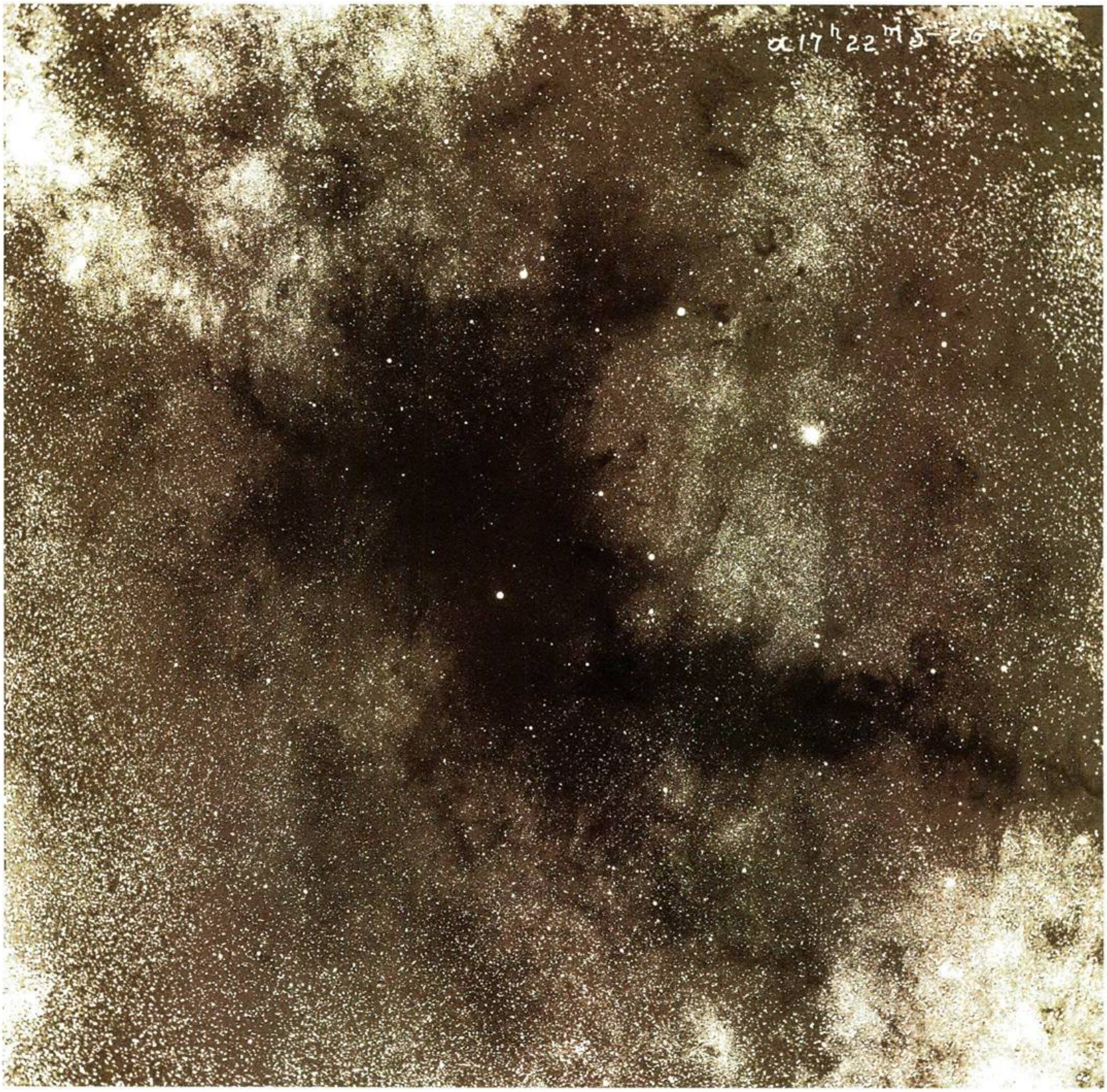
$\alpha = 17^h\, 53^m\ \delta -29°3$

THE GREAT STAR CLOUDS of Sagittarius, which Barnard described as "like the billowy clouds of a summer afternoon."

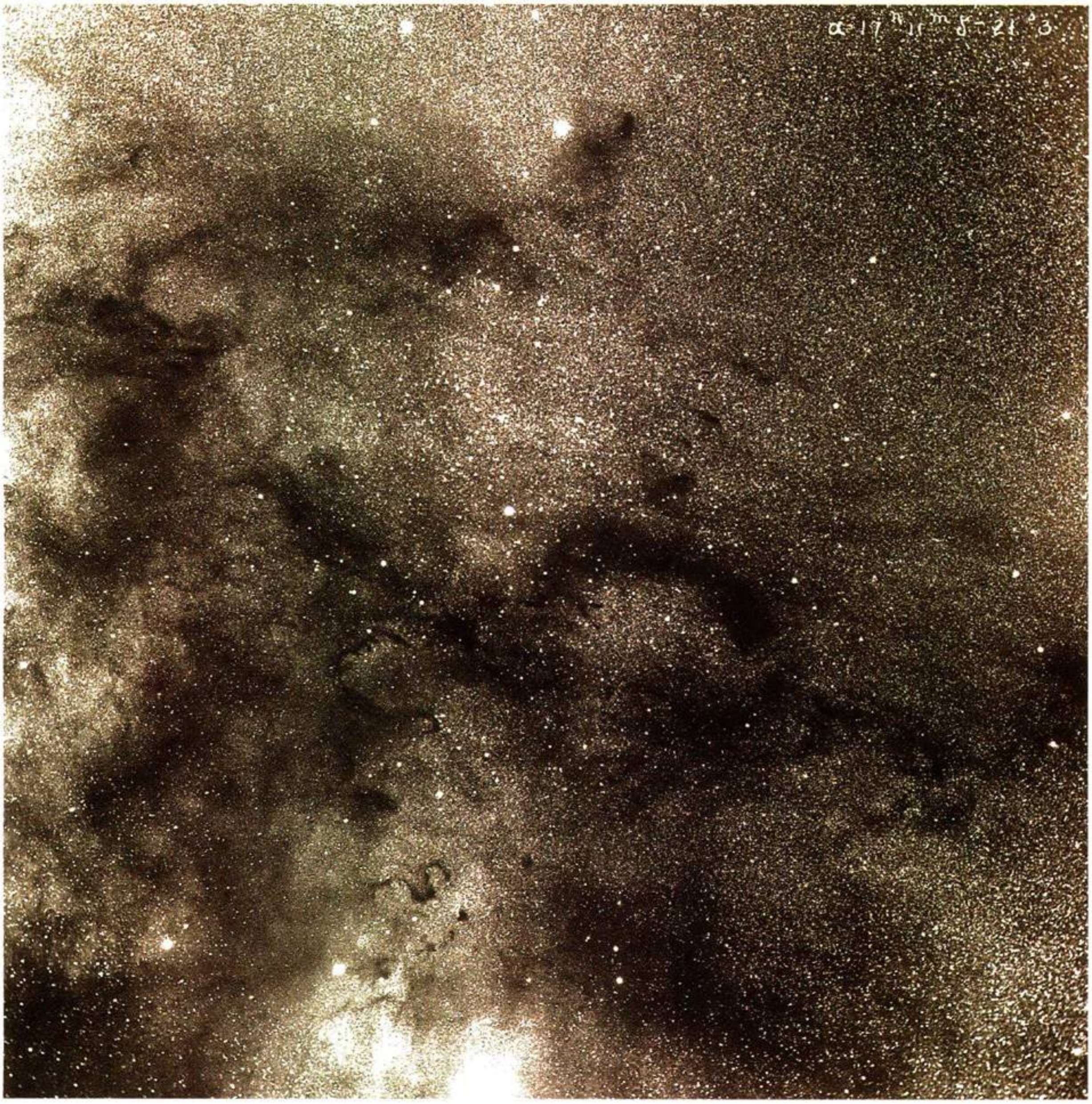
stellar region behind them."

The issue nagged at Barnard for years. After leaving Lick and arriving at Yerkes, he began casting around for a new photographic telescope, better than the primitive Willard lens, with which to raise his Milky Way photography to a higher level. He found someone willing to pay for such a telescope in a reclusive New York heiress, Catherine Bruce. The 10-inch Bruce Photographic Telescope was finished by 1904 and mounted under a tin dome on the beautiful grounds at Yerkes. Unfortunately, the skies were not as transparent at Yerkes as those at Lick, and the winters were as severe as Barnard had feared.

Hale, meanwhile, after founding the Yerkes Observatory, had headed west in search of a better site for astronomy. He set up shop on Mt. Wilson, a 5,886-foot peak near Pasadena, where he was building the Mt. Wilson Solar Observatory. Several of the younger and more promising Yerkes



THE PIPE NEBULA curves eastward from Theta Ophiuchi and occupies much of this plate. Barnard called the S-shaped object above and to the right of center "the snake," perhaps in honor of his onetime observing companion on Mt. Wilson.



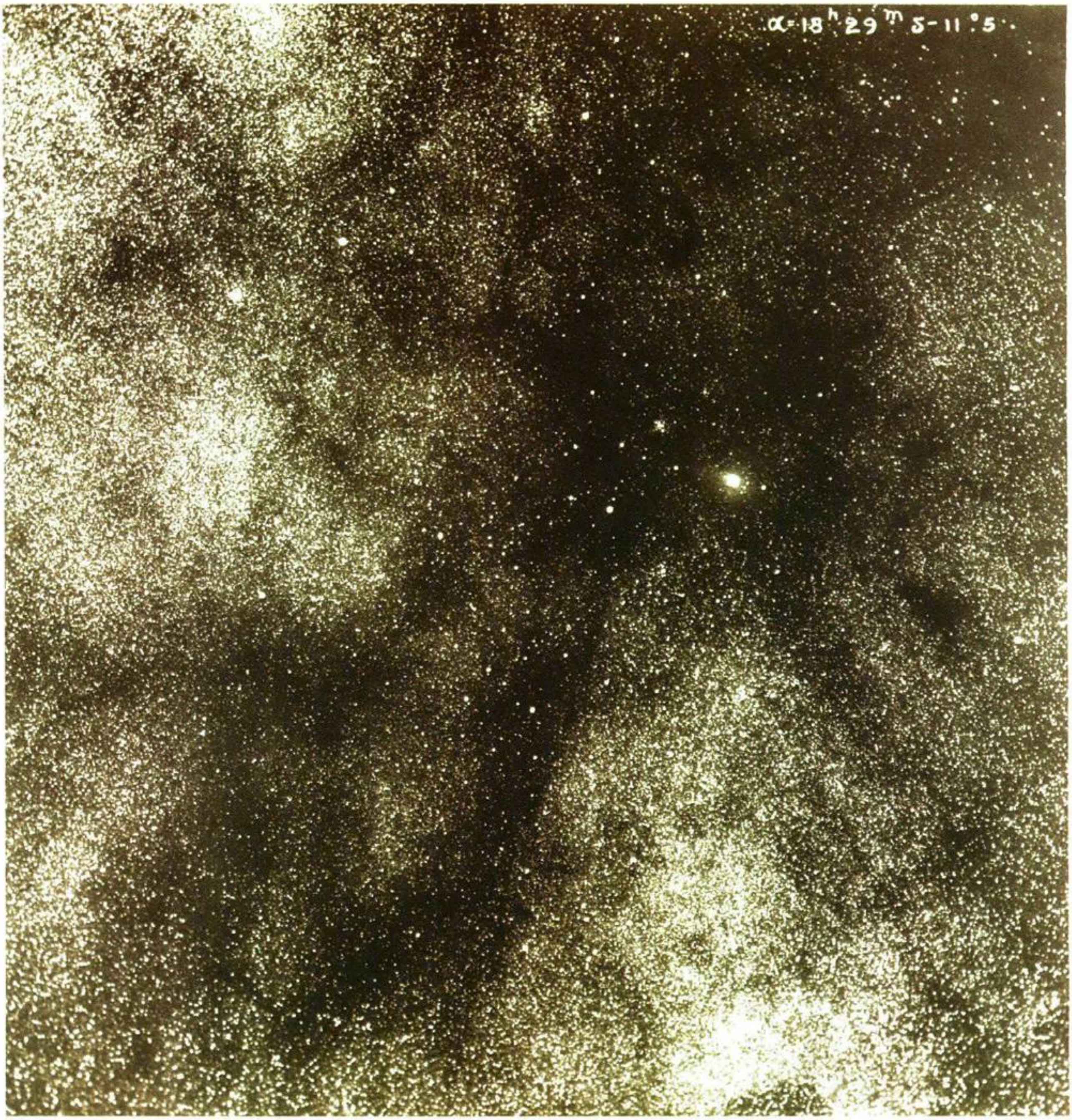
THE WILD AREA north of Theta Ophiuchi is "fuller of strange and curious things than any other regions with which my photographs have made me familiar," wrote Barnard. The S-shaped Snake Nebula lies in the lower part of the plate.

staffers had followed him west. Barnard longed to join them, but Yerkes' new director, Edwin Brant Frost, was not about to relinquish his most famous astronomer. Nevertheless, he agreed to grant Barnard a leave of absence to take the Bruce Telescope to Mt. Wilson for the purpose of photographing a more southerly portion of the Milky Way.

At the time Mt. Wilson could be reached only by what was little more than a footpath. Barnard on foot, and the 10-inch lenses fastened on each side of a mule, made the five-hour journey to the Monastery, the astronomers' quarters on the mountain, on January 10, 1905. A horse-drawn wagon hauled the Bruce Telescope to the summit. In only two weeks, he had the telescope up and running, and was exposing the first plates to the skies.

While guiding exposures, Barnard usually let his legs dangle through a trap door in the floor of the small building housing the Bruce. One morning at breakfast Barnard casually mentioned that he had been hearing rustling noises, and on investigation had discovered that a rattlesnake had been making its home there. He quipped, "It must have been a friendly snake and was there for the purpose of warming the observer's feet." The night after the snake was killed, the trap door was open as usual.

Because there was as yet no running water on the mountain, the water he used for developing his plates



A COMPLEX LATTICEWORK of dark markings between Aquila and Sagittarius appears in this exposure. The star cloud in Scutum is in the upper left.

had to be brought up the peak by a burro named Pinto. Barnard became especially fond of Pinto after he discovered that a burro's hair is finer than a human's — and thus eminently suited to making crosshairs for his guiding telescope.

Barnard maintained a superhuman work pace on Mt. Wilson. He was an obsessive observer, who was referred to as "a man who was never known to sleep." All night he guided the Bruce Telescope on the Milky Way. He kept himself going by consuming large quantities of coffee. Following breakfast with the solar observers, he spent the morning washing his photographic plates. According to one Mt. Wilson astronomer, "Barnard's hours of work would have horrified any medical man."

Barnard took 500 plates during his eight months on Mt. Wilson. The most remarkable features were the Milky Way's dark patches. Some straddled Aquila and Sagittarius. Others, east of Rho Ophiuchi, extended in long lanes that "shattered into fragments," while the wild region north of Theta Ophiuchi was "fuller of strange and curious things than any other . . . with which my photographs have made me familiar."

The appearance of the dark markings in these plates was extremely suggestive and pointed to the truth of Ranyard's earlier suggestion that light-absorbing material existed in space. Still, Barnard held back. A photograph taken with the Bruce Telescope in January 1907, after he had returned to Yerkes Observatory, showed dark or "feebly luminous" lanes coursing through Taurus. This made him verge closer to belief in the existence of dark material between the stars. The moment of epiphany, however, came "one beautiful transparent moonless night" in the summer of 1913:

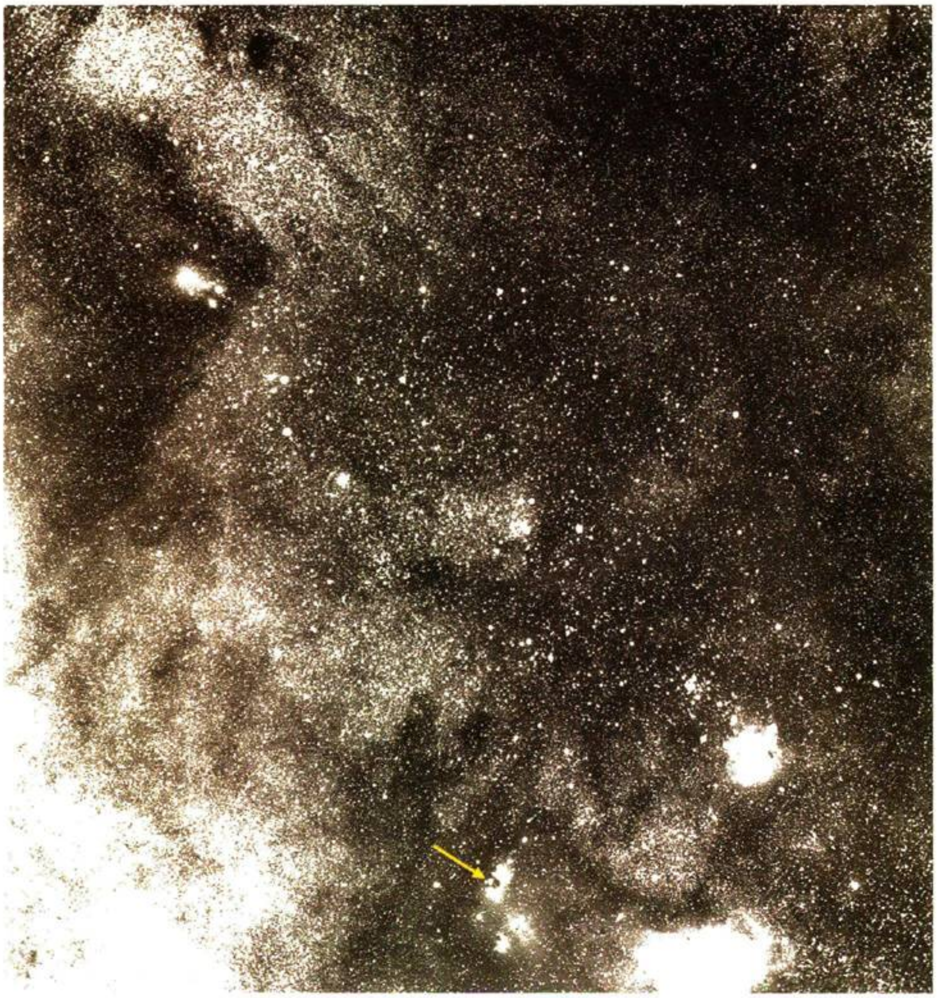
"I was struck with the presence of a group of tiny cumulous clouds scattered over the rich star-clouds of Sagittarius. They were remarkable for their smallness and definite outlines. . . . Against the bright background they appeared as conspicuous and black as drops of ink. They were in every way like the black spots shown on photographs of the Milky Way. . . . The phenomenon was impressive and full of suggestion. One could not resist the impression that many of the small spots in the Milky Way are due to a cause similar to that of the small black clouds mentioned above — that is, to more or less opaque masses between us and the Milky Way."

Thus, finally, Barnard convinced himself that space is filled with vast clouds of interstellar matter, silhouetted as dark nebulae against the powdered background of remote stars.

Barnard spent his later years at Yerkes cataloging the dark nebulae, and preparing his Bruce plates for his classic *Atlas of Selected Regions of the Milky Way*. Instead of struggling to find someone who could reproduce them to his standard, he decided to include actual photographic prints. He personally inspected each of them, 35,000 in all. It is no surprise that the work was not finished during his lifetime; it was finally published by Edwin Brant Frost and Barnard's niece, Mary Calvert, in 1927, four years after his death. At the time, prohibition-era Chicago was in the midst of its gang wars and a truck carrying copies of the *Atlas* was caught in a crossfire. One copy, with a bullet hole, was long on display at Yerkes.

Barnard's plates were taken almost a century ago, and yet despite the march of technology, they have never really been surpassed. Given his obsessive care, long-acquired skill, and trained eye, they are works of art as well as scientific standards — as apt to invoke comparisons with Ansel Adams's evocative black-and-white images of Half Dome and El Capitan at Yosemite as with later scientific records. They provide a measure of satisfaction that is in proportion to the time spent contemplating them. The black-and-white medium he used brings out in incomparable fashion the dark Monsters of Immensity which stirred him to awe and wonder. ☐

THE LAGOON AND TRIFID NEBULAE appear in the lower right of this region in Sagittarius. To the left of the Trifid Nebula (the larger of the two) is a small group of nebulous stars, in the midst of which the planet Uranus (arrowed) happened to be situated when Barnard made this exposure.



William Sheehan wrote the first full-length biography of Barnard, The Immortal Fire Within: The Life and Work of Edward Emerson Barnard *(Cambridge University Press, 1995), which was reviewed in the August 1995 issue of* ASTRONOMY.

The Fornax Dwarf Galaxy, Paul Hodge/Royal Observatory, Edinburgh

Ghost Galaxies of the Cosmos

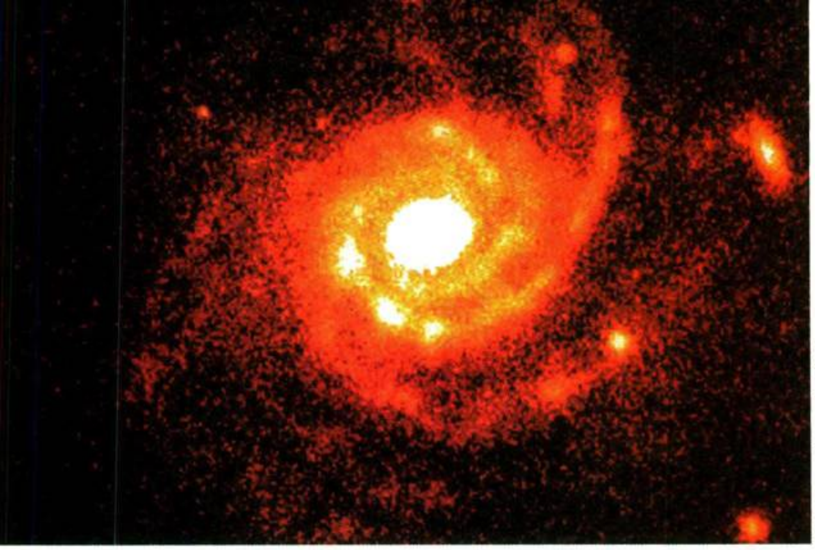
In the last decade astronomers have discovered that ghostly dim galaxies — coming in all shapes and sizes — dominate the universe.

by Chris Impey

We share a universe with ghost galaxies — dim, anemic clouds of hydrogen gas with a sprinkling of stars hiding in the shadows of intergalactic space. No larger than giant globular clusters, most of these ghost galaxies emit such diffused light that they escape detection by optical telescopes on Earth. A few of them dwarf the Milky Way and contain billions of stars. But because their stars spread over such vast expanses of space, their surface brightnesses, or apparent brightness per unit area of sky, are extremely low, typically 5 to 20 times fainter than normal galaxies with comparable masses. In other words, they are very hard to see, especially when situated very close to or distant from Earth. Astronomers call these ghosts low surface brightness, or LSB, galaxies.

LSB galaxies have recently emerged as keys to understanding the universe. Some may be infant galaxies that have formed and started producing stars very recently. Some are fossil remnants of "dead" galaxies from the ancient past. Whatever their origins, LSBs remain the most numerous type of galaxies in the universe, and they allow astronomers to see for the first time the full range of galaxy properties. LSBs also may account for copious amounts of so-called missing mass, adding another possible storehouse for the fabled missing mass of the universe.

In 1991, I teamed up with University of Arizona graduate student David Sprayberry, Greg Bothun of the University of Oregon, and Mike Irwin of the Royal Greenwich Observatory to carry out a search for LSB galaxies. We concentrated primarily on those galaxies that lurk below the brightness of the night sky. In the recently completed survey, we discovered more than 500 previously uncataloged galaxies in an equatorial strip of sky at distances of 200 to 400 million light-years. The implications were astonishing: Thirty to 100 percent more galaxies exist than astronomers had previously thought. The universe is awash with dim galaxies.



A HUGE VAULT OF HIDDEN MASS, the giant galaxy Malin 3 nonetheless has a much lower density of stars than the Milky Way. The night sky of a planet in this galaxy would contain merely dozens of stars, not thousands.

Chris Impey, University of Arizona

Blinded by the Dark

LSB galaxies were long overlooked because they are inherently difficult to find. Astronomers survey the universe from a rocky planet orbiting the Sun, which in turn lies inside an enormous disk of stars. "We are like prisoners in a lighted cell, trying to discern our whereabouts by looking through a small window to the darkness outside," says Mike Disney of the University of Cardiff in Wales. "We can see the streetlights easily enough, and the lighted windows, but can we see or correctly infer the houses and the trees?"

In the past, not every astronomer believed he was seeing all there was to see. In the 1930s, Caltech astronomer Fritz Zwicky speculated that the easily observable galaxies might make up just a fraction of the total population. Zwicky, however, was an iconoclast whose prescience (he also anticipated by many decades the importance of dark matter) was allied to a sharp and uncompromising style of doing science. Many people may have missed Zwicky's message because of the strong personality of the messenger. In the mid-1960s, Halton Arp, then working at the Hale Observatories, proposed that all the galaxies in existing catalogs had a narrow range of properties and that actually a much larger range of properties was possible. In other words, there might be different and stranger types of galaxies out there that people weren't seeing.

Arp's assertion went unvalidated until 1986, with a serendipitous discovery made by Greg Bothun and me with the help of astrophotography wizard David Malin (see "David Malin's Universe," July 1995). Using photographic amplification on plates taken with the 3.9-meter Anglo-Australian telescope, Malin noted that he could record these faint galaxies everywhere. One fuzzy blob in the direction of Virgo turned out to be about 15 times farther away than the Virgo Cluster, or about 700 million light-years away. Named Malin 1, the galaxy measures more than 700,000 light-years across, six times the diameter of the Milky Way's disk, contains ten times its gas content, and has 20 times its mass. It is the largest and most massive spiral galaxy known.

Here Come the Hidden Giants . . .

Astronomers have since found about a dozen more obscured, diffuse galaxies considered to be hidden giants. Only their central regions are visible, like the tips of icebergs, with the extended disks much fainter than the sky brightness. For example, if Malin 1 sat at the distance of the Andromeda Galaxy, it would span 20°, the width of 40 Full Moons, but even with the best telescopes we would look right through it without knowing it was there. That's because on average the enormous disk would glow weakly with only 2 or 3 percent of the brightness of the sky, its thin veil of stars barely visible. Ironically, we can see LSB galaxies more easily at larger distances, because deep but narrow CCD surveys are more sensitive than photographic surveys.

Hidden giants like Malin 1 are quite unlike the Milky Way. The density of stars in its disk is hundreds of times lower than the density of stars near the Sun. Why have so few stars formed in these giant galaxies? Theorists speculate that a low-density gas disk is stable, immune from the churning motions that trigger star formation. The enormous gas disk is rotating, which prevents material from collapsing into stars. Stars form in only a few isolated regions where very dense gas collapses under its own gravity.

A good example of a hidden giant is the faint stellar disk of UGC 6614, pictured on page 44. The photo appears alongside an image of the galaxy's donut of cold hydrogen gas observed with the Very Large Array radio telescope in New Mexico. The radio image shows that the galaxy has a copious gas supply, yet few stars have formed in the disk. It appears that galaxies like Malin 1 and UGC 6614 are relatively unevolved and contain nearly pristine material with a low abundance of heavy elements.

Astronomers generally believe that most of the galaxies we see formed from giant gas clouds when the universe was only a fraction of its current age. The larger, denser clouds collapsed quickly under the force of gravity, forming the first generation of galaxies 2 or 3 billion years after the big bang. The ghostly LSB galaxies, however, may represent galaxies that have formed recently and in our own backyard, cosmologically speaking. LSB galaxies may represent gas clouds

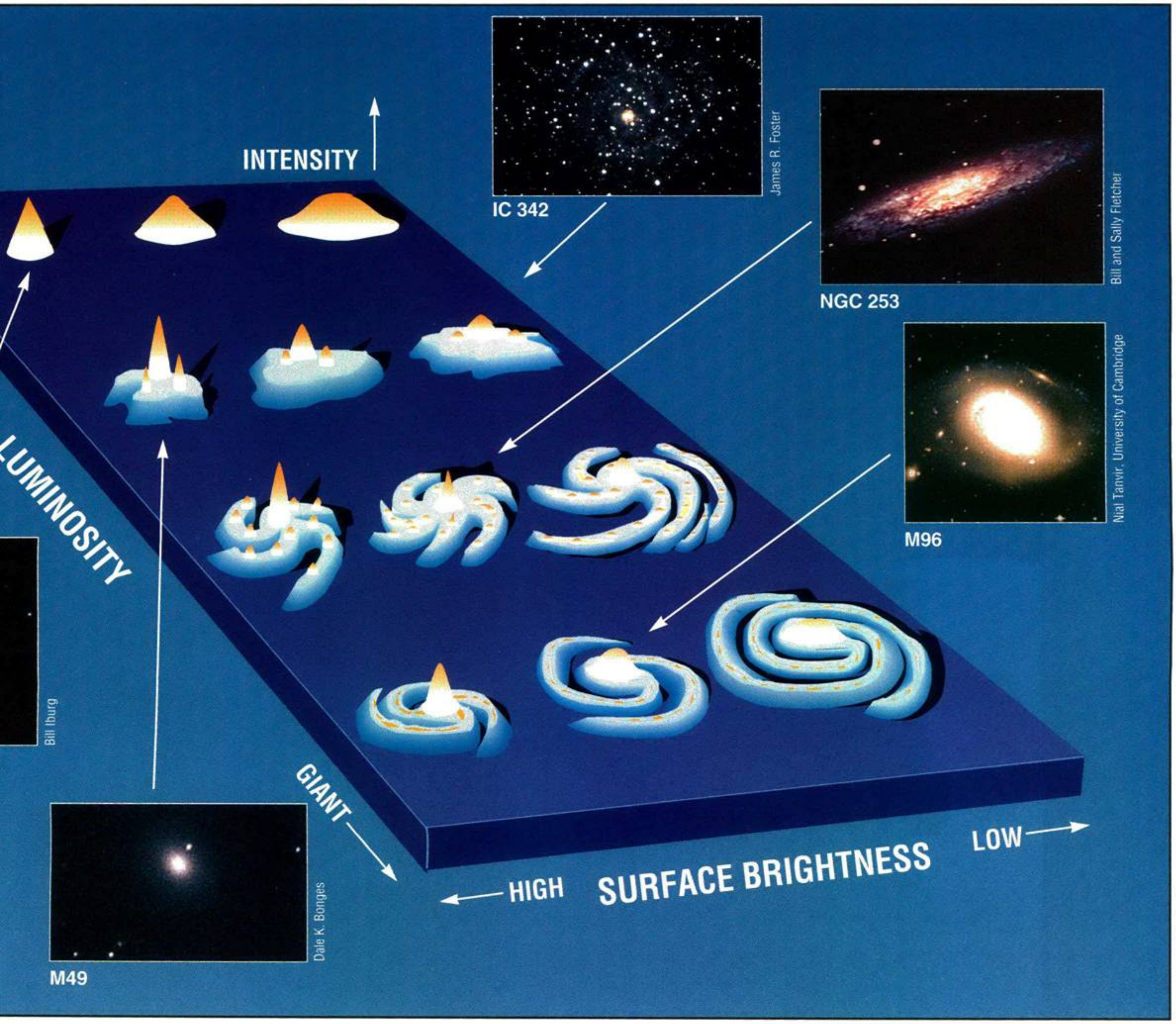
that were much more diffuse, and therefore have only now begun forming stars. If this is correct, LSB galaxies open a new window on galaxy formation and evolution because they would offer extremely young populations of stars made from ancient gas.

. . . And the Diffuse Dwarfs

At the other extreme are the dwarf LSB galaxies, the smallest of which approach the size and mass of a globular cluster. These puny stellar systems span only a few thousand light-years with a density of stars so low they barely register on a photographic plate. One of the nearest LSB dwarfs is the Fornax dwarf, shown on page 40. A dwarf companion of the Milky Way, it lies in the Local Group of galaxies, the little clump of galaxies surrounding us, only 440,000 light-years away. The Fornax dwarf is 40,000 times fainter than Malin 1. They are similar only in their low surface brightness.

Every few years astronomers discover a new member of the Local Group. Some of these galaxies are low surface brightness dwarfs. Astronomers are understandably attracted to study galaxies in the distant universe, but these discoveries make it clear that the census of the cosmic backyard remains incomplete.

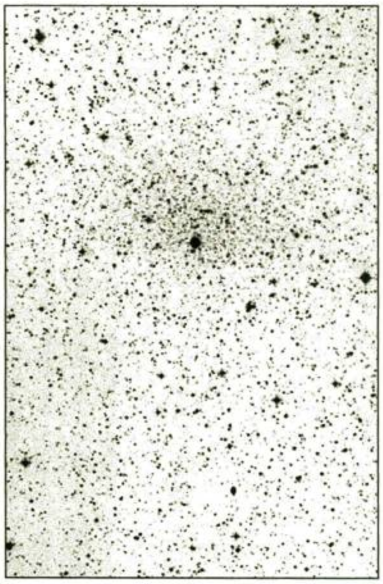
SEEING INTO THE HEARTS OF GALAXIES. Low surface brightness galaxies (along right-hand edge of diagram) run the gamut from dwarfs (upper right) to giant, Malin-type galaxies (lower right). Examples of galaxies may be found all along the spectrum.


INTENSITY
IC 342
James R. Foster
NGC 253
Bill and Sally Fletcher
M96
Nial Tanvir, University of Cambridge
LUMINOSITY
Bill Iburg
GIANT
M49
Dale K. Bonges
HIGH
SURFACE BRIGHTNESS
LOW

ASTRONOMY: Lee Vande Visse

Several dozen additional LSB dwarfs in the Local Group may await discovery.

Such LSB dwarfs elude astronomers because their individual stars appear spread out on the sky. With today's telescopes, the Fornax dwarf would prove impossible to detect at the distance of the Virgo Cluster, about 50 million light-years away, because of its low surface brightness, and because its stars would be difficult to separate from stars in the Milky Way. Based on the number of LSB dwarfs found in the local universe, these galaxies are probably the most abundant in the universe. The universe must contain trillions of these galaxies, too dim and too far away to ever be seen.



Chris Impey, University of Arizona

SPOT THE GALAXY. Low surface brightness galaxies have turned up in increasing numbers only recently, as telescopes and detectors have improved dramatically. The Fornax dwarf galaxy appears only as a slight increase in density of the stars near the center of this image.

Astronomers need to uncover all galaxy types before they can feel confident of any theory of galaxy origin and evolution.

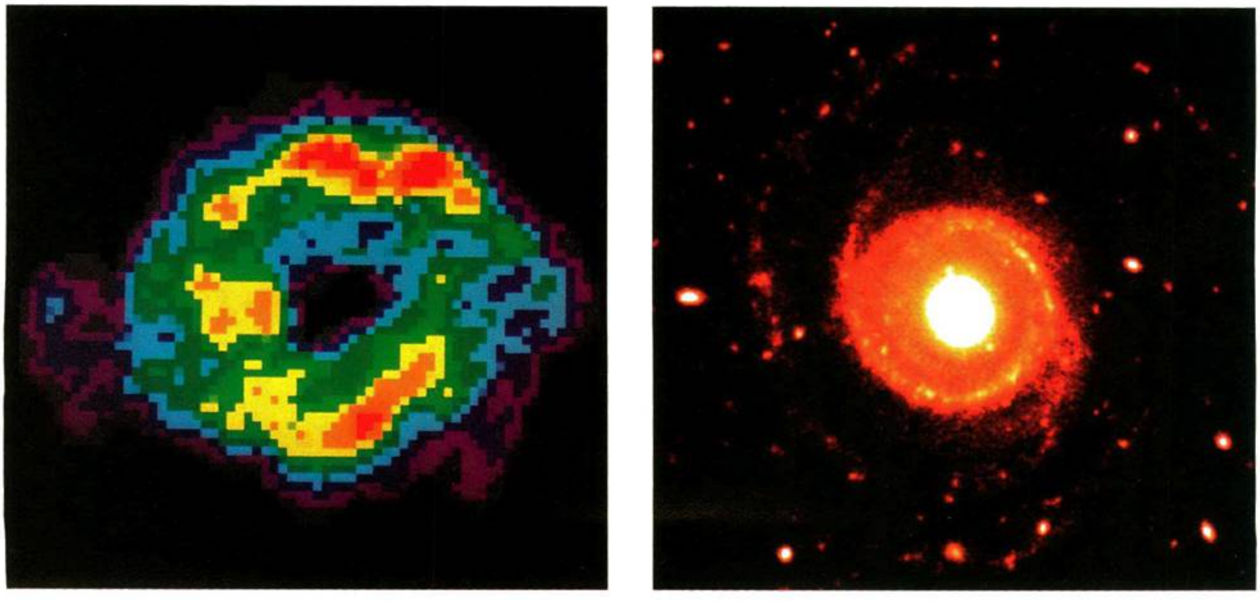
New Light on Dark Matter?

The huge numbers of LSB galaxies thought to exist may help solve a cosmological conundrum. The big bang theory predicts that normal material — matter made up of protons, neutrons, and electrons — should comprise between 1 and 5 percent of the density needed to make the universe eventually collapse back on itself. But the sum of all the luminous material seen in normal galaxies amounts to only 0.3 percent. Recent surveys indicate that black holes or brown dwarfs probably don't contribute a significant amount of mass density. Much of the shortfall can be made up with LSB galaxies. They can help solve what astronomers call the dim matter problem.

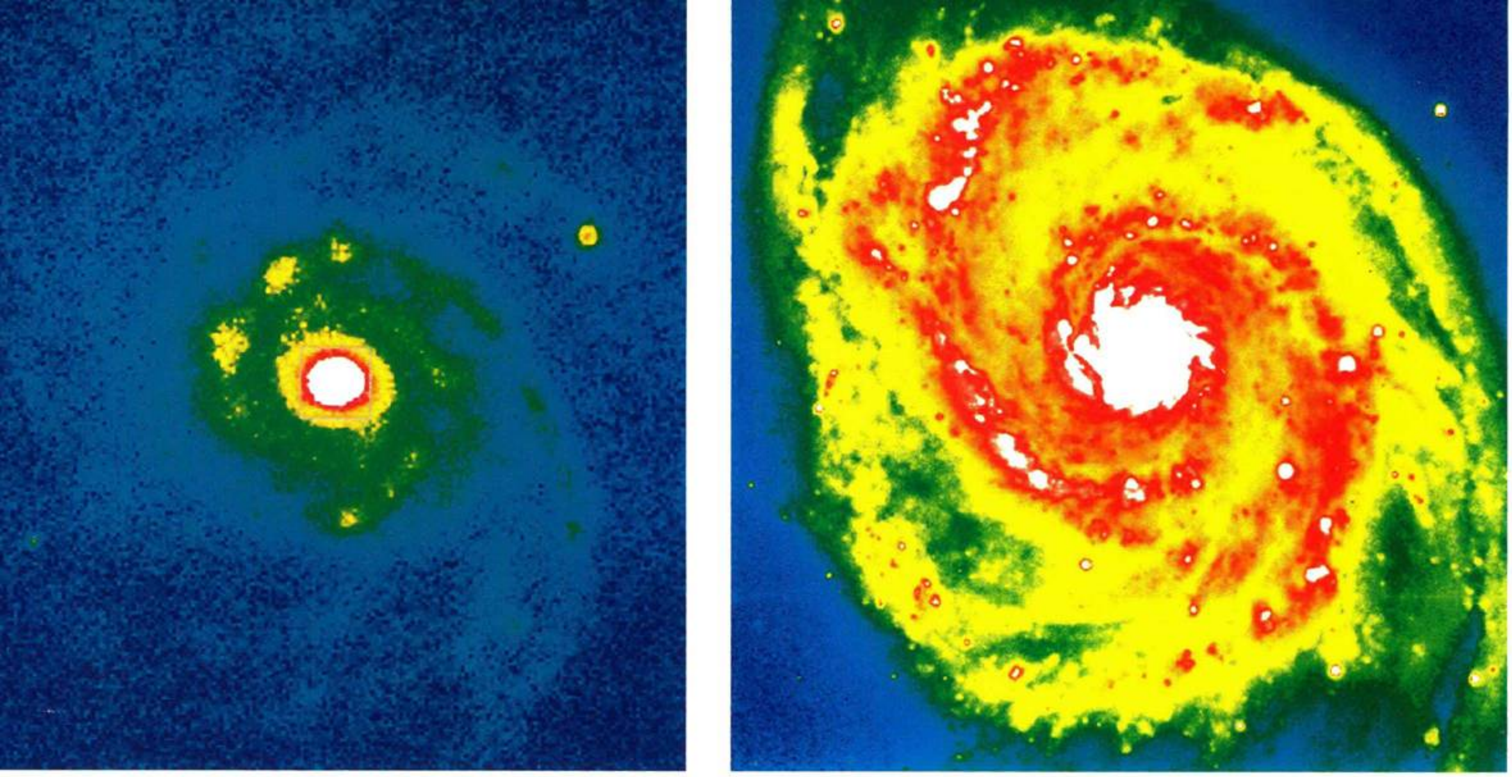
However, there is a much larger dark matter problem. If the universe balances between eternal expansion and inevitable contraction, as inflationary models predict, at least 95 percent of the universe must be exotic material. LSB galaxies impact the dark matter problem in two ways. First, they appear to contain unusually large amounts of dark matter. For the hidden giants, astronomers measure dark matter content by mapping the rotation of the gas disk. For the LSB dwarfs, astronomers measure the motions of individual stars in the galaxy.

Second, astronomers think diffuse galaxies as a class should be the most effective tracers of the distribution of dark matter. Theories of large-scale-structure formation predict that many LSB galaxies should have formed from small gravity fluctuations, and should be weakly clustered. This is because the largest gravity fluctuations form galaxies first, which then have plenty of time to strongly cluster. Small gravity fluctuations form later, consistent with the unevolved

STOREHOUSES OF THE ANCIENT, low surface brightness galaxies like UGC 6614 have relatively compact disks in visible light (right) but vast amounts of cold gas as seen in radio wavelengths (left). Despite the plentiful gas, few stars have formed in these galaxies. This suggests their material is nearly pristine like the stuff that filled the early universe.



Chris Impey, University of Arizona



Chris Impey, University of Arizona

SMALL GHOST GALAXIES are dwarfed by normal spirals. Consequently, they are hard to detect at large distances. Consider a healthy, small LSB galaxy (left) compared with the disk of the Whirlpool Galaxy, a normal spiral (right).

state of many LSB galaxies. Our new survey finds that LSB galaxies cluster more weakly than luminous galaxies, as anticipated. Normal galaxies approximate the patches of white froth at the top of an ocean swell; LSB galaxies the small ripples that give a better view of the overall distribution of water.

LSB galaxies may have extremely distant counterparts. Surveys using CCD detectors that pierce deep into the universe over small regions of sky have revealed enormous numbers of faint blue, starbursting galaxies — nearly 150,000 per square degree of sky. These faint blue galaxies, most of which are 5 to 8 billion light-years away, are five times more numerous than galaxies in our own neighborhood and unknown in the nearby universe.

Some astronomers believe LSB galaxies are the remnants of once active faint blue galaxies. Five to 8 billion years ago faint blue galaxies were fiercely forming stars, but they have since faded to near invisibility. Ed Salpeter of Cornell has dubbed such galaxies "grinning Cheshire cats" because after the stars have faded only the dark matter "grin" remains.

LSB galaxies are likely to have a variety of life stories. Some, like the hidden giants, may have formed relatively recently and are unevolved. Others may be the fossil remnants of early forming galaxies.

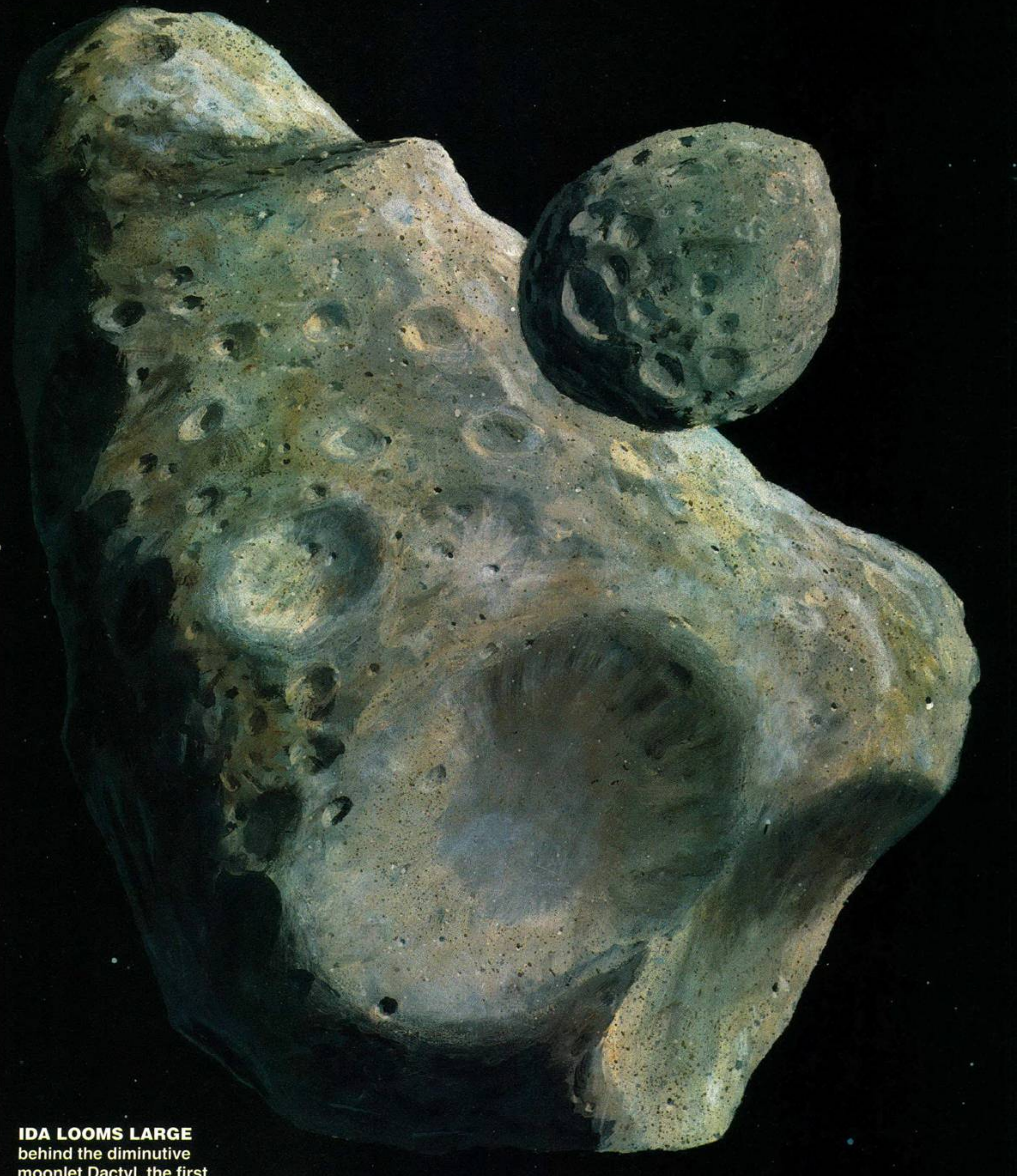
Galaxies Hiding in the Shadows

A schematic view of the visibility of galaxies appears on pages 42–43. Like their brighter cousins, LSB galaxies come in a variety of shapes. The most prominent galaxies of each type appear along the left side. The Andromeda Galaxy appears at the bottom left, and M32, a satellite of Andromeda's, at top left. Each of these galaxies has a high surface brightness. The corresponding sequence of LSB galaxies runs along the right side. At any surface brightness, there are a much larger number of dwarfs than giants.

Diffuse galaxies have begun to turn up from a number of sources. Allan Sandage, Bruno Bingelli, and Massimo Tarenghi revealed some by a monumental survey of the Virgo Cluster. Bothun and Jim Schombert of NASA have uncovered others. New digital surveys continue to refine our knowledge of these shadowy galaxies. New sky surveys like the Sloan Digital Sky Survey and a smaller CCD survey at the University of Arizona will uncover thousands of new examples. Page 43 shows a sequence of low surface brightness galaxies observed by Julianne Dalcanton at the Carnegie Observatories. Digital filtering allowed her to recover galaxies that glow feebly with only a tiny fraction of the sky brightness.

What will these new surveys tell us? They will likely give us a much clearer view of the true range of galaxy properties. The LSB galaxies they reveal will probably be good tracers of dark matter on the largest scales in the universe. The surveys are likely to affirm that astronomers have been studying only a small portion of the extragalactic zoo. As Dalcanton comments, "Low surface brightness galaxies are the proletariats of the galaxy community — overlooked, under appreciated, and everywhere." □

Chris Impey is an astronomer at the University of Arizona in Tucson currently working at the University of Washington in Seattle. He coauthored Astronomy: The Cosmic Journey, with William K. Hartmann.



IDA LOOMS LARGE behind the diminutive moonlet Dactyl, the first asteroidal satellite discovered. Images returned from Galileo have helped astronomers turn these worlds into real places.

WORLDS BETWEEN WORLDS

When the Galileo spacecraft flew past Gaspra and Ida, it helped change our view of asteroids forever.

by Clark R. Chapman

The French aviator and author Antoine de Saint-Exupéry imagined asteroids as tiny spherical worlds, with a volcano or two. One spun around each minute, causing sunrises and sunsets in rapid succession, to the delight of the young protagonist of *The Little Prince*. Asteroids were quite habitable, the author envisaged, if a bit remote and lonely.

The asteroids conceived in 1943 by Saint-Exupéry were remarkable objects, to be sure, though they were encumbered by few hard facts. Astronomers simply didn't have powerful enough tools to turn these points of light in the sky into real places. But within the last five years, the Galileo spacecraft has flown past two of these worlds, revealing them as battered, misshapen worlds — small planets, really, formed from the debris of countless collisions and possessing, in at least one case, a tiny moonlet.

Astronomers had little inkling of the remarkable nature of asteroids based on their telescopic observations during the past two centuries. Most asteroids are small and lie far away, orbiting the Sun beyond Mars in a giant donut-shaped volume of space called the asteroid belt. Observers charted their orbits by watching the unresolvable points of light move. For the larger asteroids, astronomers timed how long their days lasted by measuring how their feeble light varied. And they made guesses about their surface materials by breaking down the incoming light into its component colors. They found that not all asteroids were gray as once supposed, but showed the same range of colors as the meteorites in our museums. This led most astronomers to conclude that meteorites are debris from colliding asteroids scattered into the inner solar system. But astronomers had learned about as much as they could from Earth-based studies. To find out more required on-the-spot observations.

After launch from the Space Shuttle, the Galileo spacecraft circled the inner solar system a couple times, gaining enough energy from encounters with Venus and Earth (twice) to get out to Jupiter. During the orbital maneuvering, the spacecraft passed twice through the asteroid belt. Each time mission controllers at the Jet Propulsion Laboratory (JPL) changed its path slightly to send it very close to a favorably placed asteroid.

In October 1991, Galileo flew past the small asteroid 951 Gaspra, which orbits the Sun near the inner edge of the asteroid belt. Twenty-two months later, after transmitting the tape-recorded Gaspra data during the spacecraft's second Earth swingby, Galileo sailed out past 243 Ida. This larger object marked the final encounter for Galileo before its arrival at Jupiter in December 1995.

Thus Galileo became the first spacecraft ever to visit an asteroid. Equipped with instruments to study the Galilean moons of Jupiter, Galileo was ideally suited to examine the rocky surfaces of Gaspra and Ida. It transformed the two minor planets into fascinating worlds in their own right, and opened them to study by a different breed of scientists — geologists.

Gaspra and Ida, which is nearly five times longer than the 12-kilometer-long Gaspra, are the most angular, misshapen bodies yet seen in the solar system. Both have surfaces replete with impact craters, yet they differ greatly from each other. Nearly all of Gaspra's craters are small, less than the length of a football field. Thanks to Gaspra's minimal gravity, a space-suited asteroid miner of the future could jump across them with ease.

Ida has small craters too, but five huge craters gouge its surface (especially one half of it). Each measures around 10 km across or larger, and one digs 2 km deep. All this on an object that measures just 56 km long and less than 15 km thick at the narrowest part of its "waist." No asteroid miner could leap from crater rim to crater rim on Ida, although the gravity is still low enough that a strong-armed person could throw a baseball into orbit.

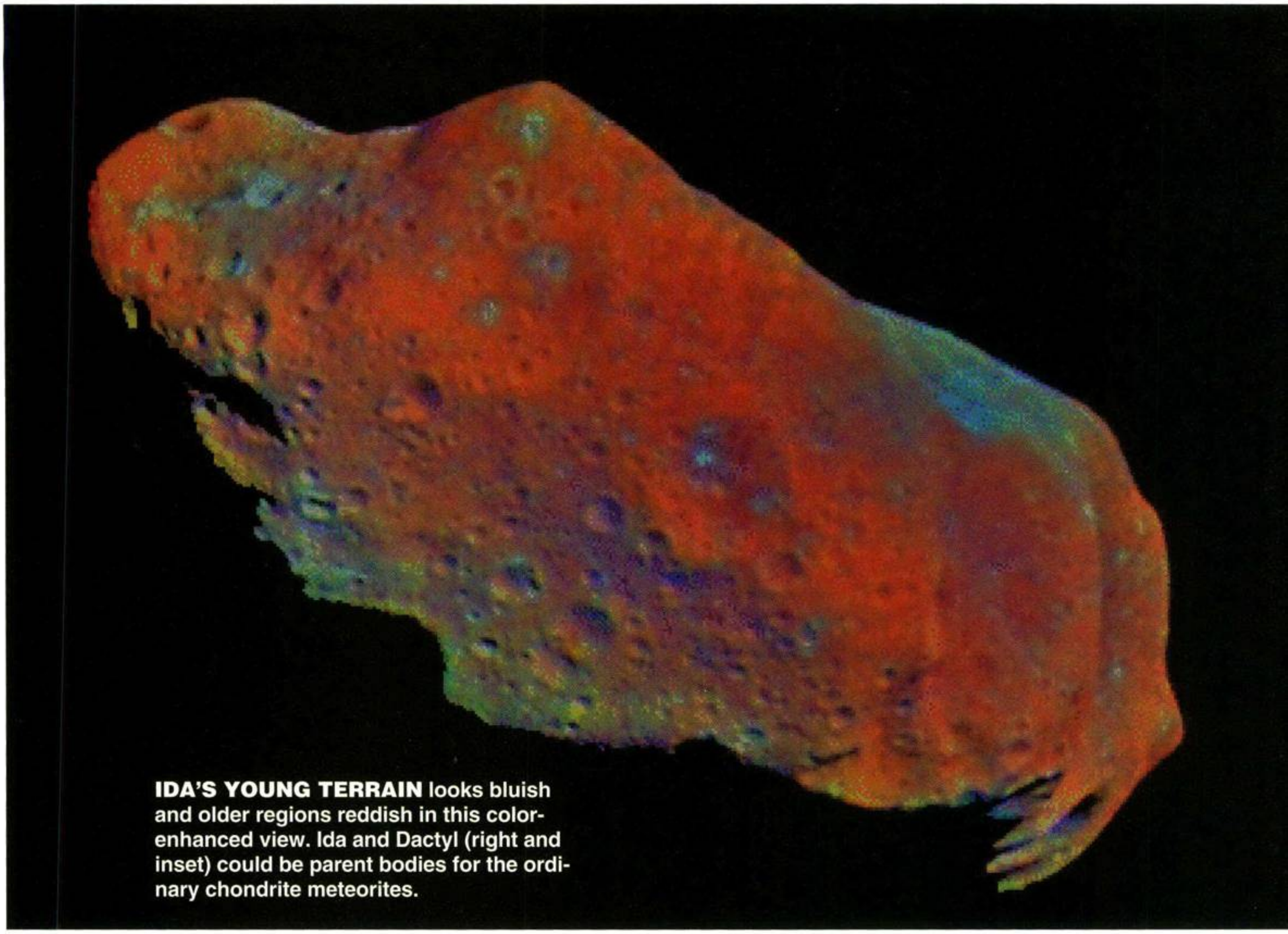
Galileo's biggest discovery en route to Jupiter was of a small moonlet of Ida, named Dactyl. Barely a mile across, Dactyl appears slightly egg-shaped, with its longest dimension pointing toward Ida. This pint-sized object is the smallest body in the solar system yet photographed up close.

Galileo researchers were surprised by the angular, faceted appearance of Gaspra's best photographed side. But other sides of Gaspra, seen less clearly from greater distances, gave a different impression: Gaspra looked almost like a double object that was somehow squashed together.

Observers have long wondered what shapes cause asteroids to vary in brightness. One idea, suggested by Don Davis and me twenty years ago, holds that some asteroids may be giant "rubble piles." Over billions of years, asteroids on intersecting orbits occasionally collide at speeds of many kilometers per second. The collisions shatter and break the bodies, and jostle the pieces about.

However, such collisions rarely supply enough energy to launch all of the larger fragments at more than the escape velocity of the ensemble. So we reasoned that the fragments, instead of dispersing, would

William K. Hartmann



IDA'S YOUNG TERRAIN looks bluish and older regions reddish in this color-enhanced view. Ida and Dactyl (right and inset) could be parent bodies for the ordinary chondrite meteorites.

reaccumulate into a rubble pile. Most of the mass of such an object might lie in the largest couple of pieces, with the smaller fragments and debris partly filling in the voids. The resulting asymmetric body would then reflect varying amounts of sunlight toward Earth.

The rubble-pile model gained credence in the late 1980s and early 90s from radar observations by JPL astronomer Steve Ostro. Using the Arecibo radio telescope in Puerto Rico and the Goldstone radio telescope in California, he found contact binaries and other lumpy objects, like 4769 Castalia and 4179 Toutatis, among the near-Earth asteroids. (See "Radar Reveals a Double Asteroid," April 1990, and "Toutatis Seen with Radar," April 1993.)

Galileo's pictures of Ida also support this model. Most of the asteroid comprises two main chunks, separated by a narrow waist and bent with respect to each other, yielding an overall shape reminiscent of a thick banana. The two chunks bear little resemblance to each other. The six largest craters and nearly all the mysterious "grooves" reside on one part; most of the hundred-meter-scale boulders are on that part, too.

The other, slightly larger, chunk contains a prominent ridge, more planar surfaces, and lots of smaller craters (including some with dark floors), but no large craters. One large, peculiar, saddle-shaped feature, Vienna Regio, could have been caused by an impact near one end of Ida. Maybe that event seismically shook the chunk of Ida it is on, eradicating much of the pre-existing topography. Or perhaps seismic waves from the impact traversed the interior of Ida and were focused at the opposite end, cracking the surface and forming the grooves there.

Many Galileo researchers view the stark differences between Ida's two main chunks as evidence that Ida is probably a rubble pile. But they don't know for sure because the asteroid's interior remains hidden. After all, the photos show directly only Ida's surface.

On the other hand, Galileo's images of Gaspra hint that this asteroid is a strong shard from the catastrophic disruption that created it, perhaps subsequently whittled away by large impacts.

Just because planetary scientists can't peer inside these asteroids doesn't mean they remain in the dark about their geology. On Earth, geology usually means faults, rivers, mountains, volcanos, and other landforms. These simply don't exist on aster-

NASA/JPL

NASA/JPL

oids, which are small, inert bodies that can't generate the heat and internal contortions that drive many geological processes on Earth. Instead, the energy that drives the geology of asteroids comes from violent, high speed impacts. Because most of the projectiles that have cratered Gaspra and Ida would burn up in Earth's atmosphere before reaching the ground, few geological processes on these asteroids have a terrestrial analog.

Ida's complex geological environment proves far from intuitive. Even gravity doesn't work the way you'd think. On Earth, gravity varies from place to place by at most a few tenths of one percent. Yet two places on Ida have a gravity less than one-third that of where it is greatest! One lies near an end of Ida, where the centripetal force of the asteroid's rapid 4.6-hour spin and the end's distance from most of the mass of Ida combine to yield low gravity. The other occurs at the bend in Ida's waist, which lies almost ten times closer to Ida's center of mass than the farthest end. At the waist, much of Ida's mass gravitationally tugs *away* from Ida's center of mass, not toward it. Ida's strange gravity field means that debris blasted from the surface by an impact will follow odd trajectories and form patterns far different from the nice symmetric patterns you find on larger bodies like the Moon.

A soil layer of fine debris, called regolith, generated by repeated impacts, covers Ida's surface to a depth of at least 150 meters. In places, geologists recognize chutes formed by landslides of debris. Most of Ida's craters, unlike those on Gaspra, appear much more shallow and degraded than newly formed craters because they are partly filled in by regolith and debris ejected from more recent impacts.

Apparently some surface debris has also moved down slope on Gaspra. But Gaspra seems to have a much thinner layer of regolith, perhaps only a few meters thick. This comes as no great surprise because Gaspra's smaller mass gives it a lower escape velocity (only a few meters per second), and many fragments created during an impact simply escape the asteroid's gravitational clutches. On Ida, most ejecta — at least that coming from larger impacts — reimpact elsewhere on the surface, although the debris spreads much more widely than from an impact on the Moon.

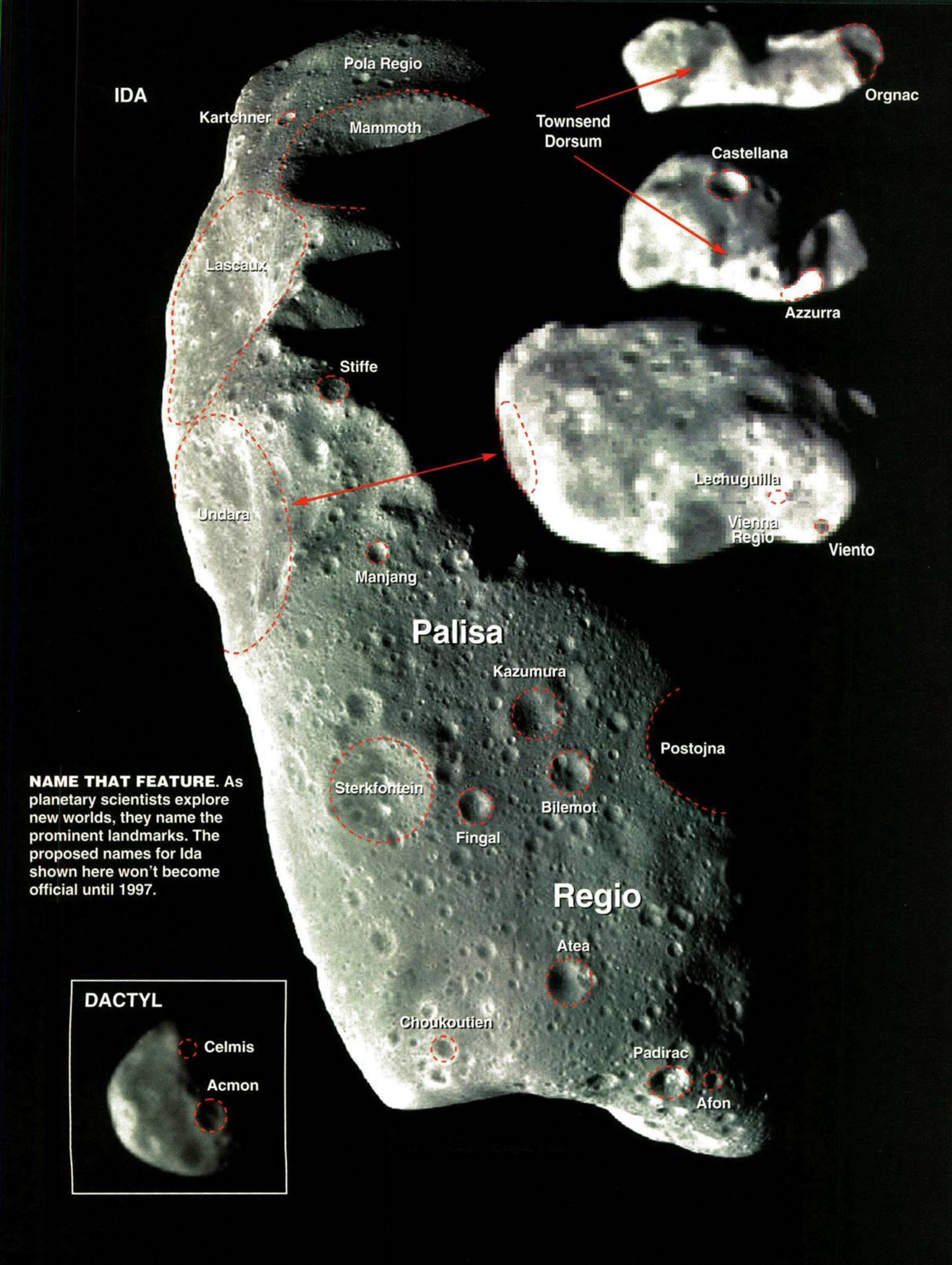
Paul Geissler of the University of Arizona has modeled where ejecta should have landed from the largest recent impact on Ida, which formed the bright crater named Azzurra. The calculated ejecta pattern matches almost exactly the widespread but patchy distribution of bluer-than-average colors on Ida (see page 51). Evidently, the recently excavated material has not been around long enough to be affected by the process that gradually darkens and reddens Ida's surface materials, so it partially retains the bluer color that seems to characterize deep regolith or bedrock on Ida.

Azzurra's ejecta pattern yields an important clue about the colors of Ida's surface, and may help resolve one of the most vexing problems in asteroid science: Where do the ordinary chondrite meteorites come from? These space-rocks — made of the common silicate minerals olivine and pyroxene but also loaded with tiny flecks of nickel-iron metal — dominate museum collections, so they must also be abundant in space.

Geologists and astronomers can identify minerals in a rock by measuring precisely the rock's "colors" (actually the spectrum of sunlight reflected from the rock). In fact, spectra matching all common meteorite types have been found among asteroids in the inner half of the asteroid belt, where most meteorites are expected to originate. And the numbers of asteroids are roughly proportional to the frequency of meteorites — except for the ordinary chondrites. Only one tiny asteroid has a spectrum resembling these meteorites; intensive searches have turned up no others.

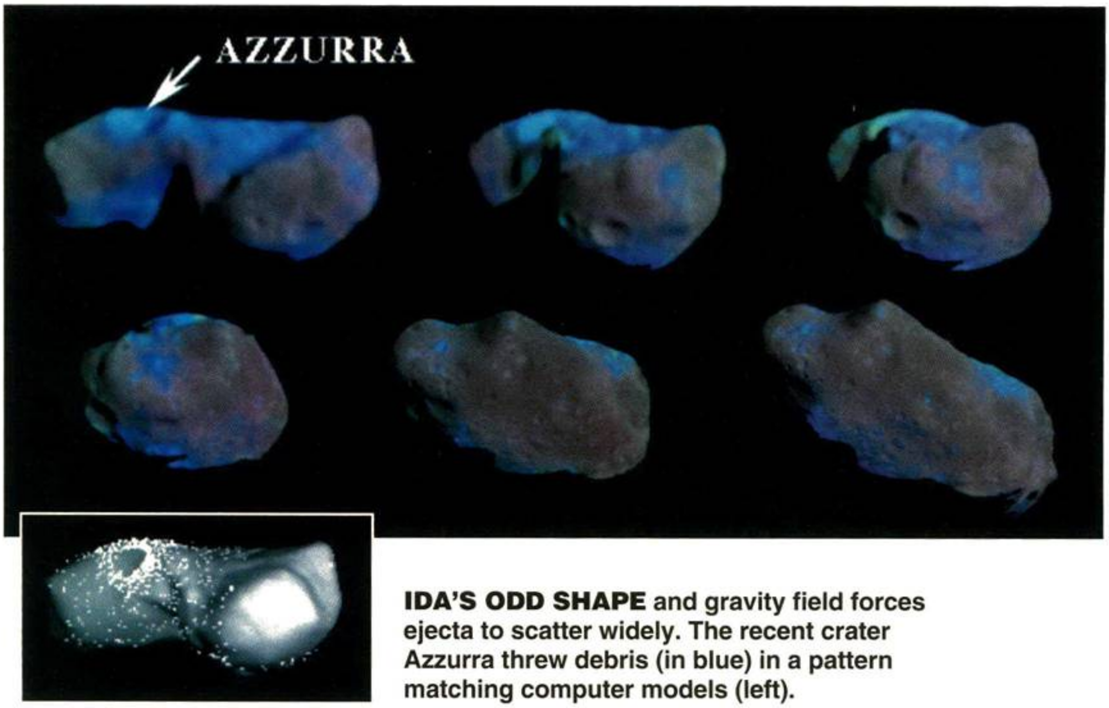
When you find pebbles of a certain color in a stream, it implies that there must be a cliff upstream containing rocks of the same color. So it is with meteorites and asteroids, *unless* something changes the colors of materials exposed to interplanetary space on an asteroid surface. Indeed, such "space weathering" makes the lunar surface much redder than the color of pristine Moon rocks.

Galileo has found that space weathering operates on Ida, too, though no one knows just how it alters colors. Maybe it's by radiation damage, minor physical or chemical changes caused by impacts, or sorting processes on a low-gravity world lacking an atmosphere. Besides Azzurra's ejecta, several small, deep, recent craters have excavated material more like ordinary chondrites than the bulk of Ida's redder surface. (Dactyl, whose surface is less likely to be space-weathered, has a spectrum even closer to ordinary chondrites than the younger regions of Ida.) Ida belongs to


IDA
Pola Regio
Kartchner
Mammoth
Lascaux
Stiffe
Undara
Manjang
Palisa
Regio
Kazumura
Postojna
Sterkfontein
Fingal
Bilemot
Atea
Choukoutien
Padirac
Afon
Townsend
Dorsum
Orgnac
Castellana
Azzurra
Lechuguilla
Vienna
Regio
Viento
DACTYL
Celmis
Acmon

NAME THAT FEATURE. As planetary scientists explore new worlds, they name the prominent landmarks. The proposed names for Ida shown here won't become official until 1997.

an abundant class of asteroids — named the S-IV types — that are all candidates for the parent bodies of ordinary chondrites, provided that their colors are also reddened by space weathering. Galileo may have helped solve the mystery of the ordinary chondrite parent bodies.



IDA'S ODD SHAPE and gravity field forces ejecta to scatter widely. The recent crater Azzurra threw debris (in blue) in a pattern matching computer models (left).

Paul Geissler, Lunar and Planetary Lab

NASA/JPL

Unfortunately, astronomers can't travel back in time to watch the catastrophic collisions that presumably produced Ida and Gaspra, so we will never know exactly how they were created. But we now have a pretty good idea. Apparently a gigantic collision, occurring perhaps 1 or 2 billion years ago, catastrophically disrupted an object somewhat larger than 100 km across. That collision created the Koronis family of asteroids, including Ida. (See "All in the Family," February 1993.)

Evidently the composition of the Koronis parent body was nearly homogeneous, because all the larger members have essentially identical colors and spectra (they are S-IVs). Extrapolating from our interpretation of Ida and Dactyl, it may be that all the Koronis family members are made of ordinary chondrite material. This idea is, at least, a valid alternative to the prevailing view, proposed by Jeff Bell of the University of Hawaii, that the source of ordinary chondrites is a collection of tiny main-belt asteroids too small to have been studied yet by Earth-based astronomers.

Astronomers have learned less about Gaspra than Ida. Gaspra's spectrum clearly shows it can't be an ordinary chondrite object, though it might be a stony-iron body. If it's as strong as some stony-iron meteorites, Gaspra would be much more resistant to cratering and impacts than rocky asteroids. Despite Gaspra's lack of large craters, which Galileo researchers initially took to mean that the asteroid was "only" a couple hundred million years old, it could be a strong, ancient remnant from the epoch of the solar system's birth. Maybe a later mission to one of Gaspra's cousins can test this conjecture.

The mere existence of Dactyl has caused planetary scientists, who once doubted that satellites could form around asteroids, to revise their calculations. The new view holds that the catastrophic collisions that form asteroid families should almost inevitably give rise to tiny satellites orbiting large family asteroids. During such major collisions, fragments would be shot away in various directions. Calculations show that most fragments would be accompanied by a much smaller object following a nearly identical trajectory, and that the larger object would be able to capture the smaller one into orbit.

We don't know how long such satellites might last before their orbits become unstable and they crash, escape, or get smashed to bits by a subsequent impact. But the presence of Dactyl gives hope that asteroidal satellites, at least small ones, might be numerous.

Galileo's reconnaissance has opened an era of geological analysis of asteroids. This past February 17, the Near Earth Asteroid Rendezvous (NEAR) spacecraft was launched from Cape Canaveral. It will fly past the large main-belt C-type asteroid 253 Mathilde in 1997. Then, for most of the year 1999, it will orbit the Earth-approaching asteroid 433 Eros. (Eros is a highly elongated S-type asteroid, intermediate in size between Gaspra and Ida.)

NEAR will become the first dedicated mission to an asteroid. The year-long rendezvous will permit imaging and spectral mapping far beyond what Galileo's flybys could achieve. Moreover, X-ray and gamma-ray instruments on NEAR can make definitive analyses of the asteroid's chemistry and mineralogy. Finally, scientists will use the gravitational effect of Eros on NEAR to accurately determine the mass of the asteroid and from that its bulk density.

The Arecibo radio telescope also waits in the wings. With its upgrade expected to be complete next year, it soon will be able to make radar maps of some Earth-approaching asteroids that will rival Galileo's imaging of Gaspra. By the turn of the century, planetary geologists should have a zoo of asteroids to study. More surprises are surely in store for us. ☐

Clark R. Chapman is a planetary scientist at the Planetary Science Institute in Tucson, Arizona. He coauthored "Interplanetary Fugitives" in the August 1992 issue.

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***ASTRONOMY*, February 1991**

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Helix Nebula, NGC 7293 in Aquarius. Bright and easy with Lumicon Oxygen-III Filter.

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DEEP-SKY ASTROPHOTOGRAPHY

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†U.S. Patent 4,473,636

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5. **LUMICON EASY-GUIDER** (selection to left)

6. **LUMICON 48mm DEEP-SKY FILTER $119.50**
This is essential for highest possible contrast. Contrast is boosted up to 3X for ***both*** color or black & white photos. The 3 photos in this ad showing the Helix Nebula, Horsehead Nebula and Veil Nebula were all made using a LUMICON 48mm DEEP-SKY FILTER.

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NEW! 7'' - 10'' LX50

16'' LX200 $14,950
8'' LX50
$1395

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LX50 - includes dec. motor, hand controller.
LX200 - full computer control w/64K obj. mem.
Tripod: extra for LX50; included for LX200
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NEW! 8'' LX50 w/wedge, dec. motor, hand controller ($105 P&S)	**$1395**
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PHOTOGRAPHY ACCESSORIES

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New 8'' f/6 Meade Starfinder telescopes

See the Meade ad in this magazine for full descriptions. These are complete telescope systems with motor drive & finderscope (equat. only), mount, and 25mm (=48X) eyepiece. New DC motor runs on 4AA batteries.

6'' f/8 Dobsonian Starfinder ($46 P&S)	**$349**
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10'' f/4.5 Equat. Starfinder 10 (add $99 P&S)	**$879**
12.5'' f/4.8 Dobsonian Starfinder ($95 P&S)	**$895**
16'' f/4.5 Dobsonian Starfinder (freight COD)	**$1195**
16'' f/4.5 Starfinder 16 (ship. freight COD)	**$2695**

*All Starfinder telescopes shipped directly from Meade to the purchaser. Please add the indicated packing & shipping charge to the price. Slightly lower P&S for payment by check. LUMICON showroom prices are $50-$100 higher.

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Includes Computer, Encoders, Hardware

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NGC SKY VECTOR with IDENTIFY (Sky Tour) mode, 12,000 object memory including the corrected RNGC catalogue, IC catalogue, P&K planetary catalogue, & much more!

Specify Telescope Type: Meade 2045, 2080, 2120, C-8, C-11, Odyssey 8, 10, 13, 17½, Alt-Azimuth, Meade 6-16'' Dobsonian.

Ultima 8, 9¼, 11 **add $25**, C-14 **add $75**

COMA CORRECTOR

Coma 1 inch off-axis 17½'' f/4.5

Same field with LUMICON coma corrector; smaller, more numerous stars.

This computer-designed LUMICON 2'' lens reduces coma and flattens the field for both viewing and photography. **It threads into LUMICON 2'' EASY-GUIDERS for effortless installation.** This zero power lens does not change image scale nor shift focus, and all lens surfaces are multi-coated for highest efficiency. Clear aperture = 1.8''.

LUMICON 48mm Coma Corrector/Field Flattener Lens	**$285.00**
LUMICON 2'' EASY-GUIDER	**$189.50**
2'' EASY-GUIDER (Mamiya 645)	**$239.50**
2'' Adapter for Pentax 6X7	**$129.00**
2'' Adapter for Hasselblad	**$229.00**
2'' Adapter for Bronica SQ-A	**$175.00**
2'' Extension for viewing	**$26.00**

2'' DELUXE BARLOW

1.8x Multiplier Lens (2'' Barlow)

LUMICON 1.8x Multiplier Lens (2'' Barlow)	**$259.00**

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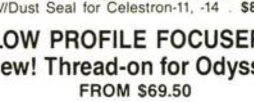
LARGE UV/DUST SEAL



Protect the optics of your 8-14'' Schmidt-Cassegrain with a UV/Dust Seal. Simply thread it onto the rear cell, then attach all normal accessories. The large size fits Meade 2120, Celestron-11 and -14 & has a high quality multi coated (removable) 72mm UV filter.

Deep-Sky Filter/Dust Seal for C-8, 2080	**$119.50**
UV/Dust Deal for Celestron C-8	**$39.00**
UV/Dust Seal for Meade 2080, 2045	**$39.00**
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New! Thread-on for Odyssey

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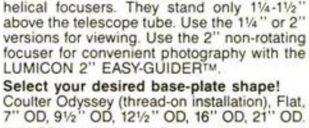


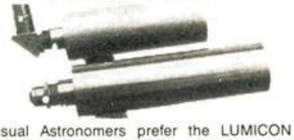
LUMICON® LOW PROFILE FOCUSERS

LUMICON now offers 3 different low-profile helical focusers. They stand only 1¼-1½'' above the telescope tube. Use the 1¼'' or 2'' versions for viewing. Use the 2'' non-rotating focuser for convenient photography with the LUMICON 2'' EASY-GUIDER™.

Select your desired base-plate shape! Coulter Odyssey (thread-on installation), Flat, 7'' OD, 9½'' OD, 12½'' OD, 16'' OD, 21'' OD.

LUMICON 1¼'' Helical Focuser	**$69.50**
LUMICON 2'' Helical Focuser 1½'' high	**$75.00**
LUMICON Non-rotating Helical Focuser	**$129.00**
2'' Astro Systems focuser, only 2'' high	**$139.00**
3 handles for non-rotating focuser	**$12.95**
2''/1¼'' **adapter** w/48mm filter threads	**$20.00**
2'' LUMICON EASY-GUIDER	**$189.50**

LUMICON 50mm, 80mm SUPER-FINDER™



Visual Astronomers prefer the LUMICON 80mm SUPER-FINDER™, since hundreds of deep-sky objects, including most Messier objects, are visible directly. SUPER-FINDERS also make nice small portable telescopes. 80mm aperture, F=300mm coated achromat or 50mm, F=200mm coated achromat. Eyepieces and/or star diagonal are extra.

1¼'' 50mm Finderscope **$69.50**, right-angle	**$69.50**
1¼'' straight-thru 80mm SUPER-FINDER	**$189.50**
1¼'' right-angle 80mm SUPER-FINDER	**$199.50**
1¼'' right-angle version, w/star diagonal	**$239.50**
25mm Cross-hair 1¼'' eyepiece (12X)	**$59.00**
Large mounting rings for 80mm Finder	**$55.00**
1¼'' Star Diagonal **$49**, Mounting Brackets,	**$39.50**
1¼'' 45° diagonal for correct left-right views	**$59.50**

LOTS OF ADAPTERS

2'' adapter for C-8, Meade 2080, etc.	**$29.50**
2'' adapter for C-80, C-100 refractor	**$39.50**
2'' adapter for C-70, C-80F, C-100F fluorite	**$39.50**
2'' adapter for C-6, Comet Catcher, Meade 312	**$30.00**

EXTENSION TUBES

1'' long 1¼'' OD thread-in extension	**12.00**
2½'' long extension (holds 1¼'' filters)	**19.50**
4½'' long extension for 1¼'' eyepieces	**$29.00**
3'' long extension for 2'' eyepieces*	**$29.00**
2'' long extension for 2'' eyepieces*	**$29.00**

VIEWING ADAPTERS

2''/1¼'' reducing bushing,threaded 48mm*	**$25.00**
2''/T-thread adapter, threaded 48mm*	**$25.00**
T-thread/1¼'' adapter	**$25.00**
F/10 2'' or 1¼'' eyepiece viewing adapter for Giant Easy-Guider	**$39.50**
Low profile star diagonal eyepiece holder	**$16.00**
Meade 2'' Diagonal/Giant Easy-Guider	**$39.50**

**Threaded to hold 48mm filters.*

ALMANAC

A pair of Full Moons turns June blue, a pair of bright comets calls Sagittarius home, and a pair of planets have satellites that bear watching.

by Jeff Kanipe

Highlights
by Rick Shaffer

Date	Event
30	**First Views:** A Blue Moon for June . . . .(p. 59)
all month:	Venus in the Morning . . . . .(p. 59)
	Clash of the Comets in Sagittarius . . .(p. 60)
	Ceres Introduces a Double . . . . . .(p. 60)
	Observer's Challenge: Saturn's Disappearing Moons . . . . . .(p. 61)
	View the Jovian Satellite Action . . . .(p. 62)
	The Globulars of Hercules . . . . .(p. 63)

The month of June begins — and ends — with a Full Moon. At sunset on June 1, it rises above the trees like a yellow Chinese lantern in the east-southeast. The June Full Moon is called variously the Rose Moon, Flower Moon, or Strawberry Moon (take your pick).

Then on June 30, another Full Moon graces the east-southeastern sky at sunset. This Moon, the second Full Moon of the month, also has a name: "Blue Moon." True to its name, Blue Moons don't occur often — on average once every 2.72 years.

Not everyone on Earth experiences a Blue Moon this month. If we synchronize our watches to Universal Time — the mean solar time in Greenwich, England — then the second Full Moon of June actually occurs on July 1 at 3:58 a.m. No Blue Moon for Europe this month. There is, however, a four-hour time difference now between Greenwich and the east coast of the United States. Thus, when it's 3:58 a.m. in Greenwich, clocks on the east coast read 11:58 p.m. Eastern Daylight Time on June 30. Two minutes is two minutes, and in this case, it buys the States a true Blue Moon in June!

Turning to planets, you may be able to catch **Venus** very low in the west-northwest just after sunset. Look now if you want to see it. Venus disappears early this month, hurrying to meet its appointment with the Sun on June 10. It then returns to the morning sky, low in the east-northeast, in the final two weeks of June.

The only other solar system object in the early evening sky at the start of June requires a telescope to be seen. Not quite two weeks past opposition, **Pluto** lies in far western Ophiuchus and is well placed for those up to the challenge of searching for this remote object. Check out the finder chart on page 70 in last month's issue of ASTRONOMY.

Shining through the dusk a half-hour after sunset in early June, yellowish Procyon in Canis Minor the Lesser Dog marks cardinal west. To its right (north), we see Gemini the Twins alighting upright on the western horizon. The two brightest stars of this zodiacal group lie side by side in the sky. They are Castor on the right and Pollux on the left. Castor is a beautiful binary system consisting of 2nd- and 3rd-

Larry Landolfi

A BLUE MOON OVER MANHATTAN spices up New Year's Eve in 1990.

JUNE

1 Full Moon is at 4:47 p.m. EDT

3 The Moon is at perigee (224,620 miles from Earth), 12:17 p.m. EDT

4 The Moon passes 5° north of Jupiter, 2 a.m. EDT

8 Last Quarter Moon is at 7:05 a.m. EDT

9 The Moon passes 3° north of Saturn, 6 p.m. EDT

10 Mercury is at greatest western elongation (24°), 5 a.m. EDT
Venus is in inferior conjunction, noon EDT

13 The Moon passes 0.4° south of Mercury, 8 p.m. EDT
The Moon passes 4° south of Mars, 9 p.m. EDT

14 Mercury passes 3° south of Mars, 9 a.m. EDT

15 New Moon is at 9:36 p.m. EDT

19 The Moon is at apogee (252,297 miles from Earth), 2:24 a.m. EDT

20 Summer solstice is at 10:24 p.m. EDT

21 Mercury passes 4° north of Aldebaran, 7 a.m. EDT

23 Mercury passes 1.6° north of Venus, 8 a.m. EDT

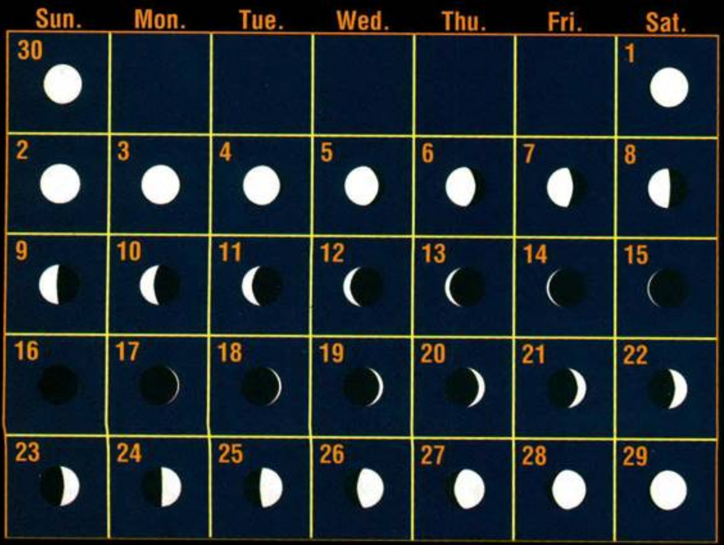
24 First Quarter Moon is at 1:23 a.m. EDT

27 Mars passes 6° north of Aldebaran, 8 a.m. EDT

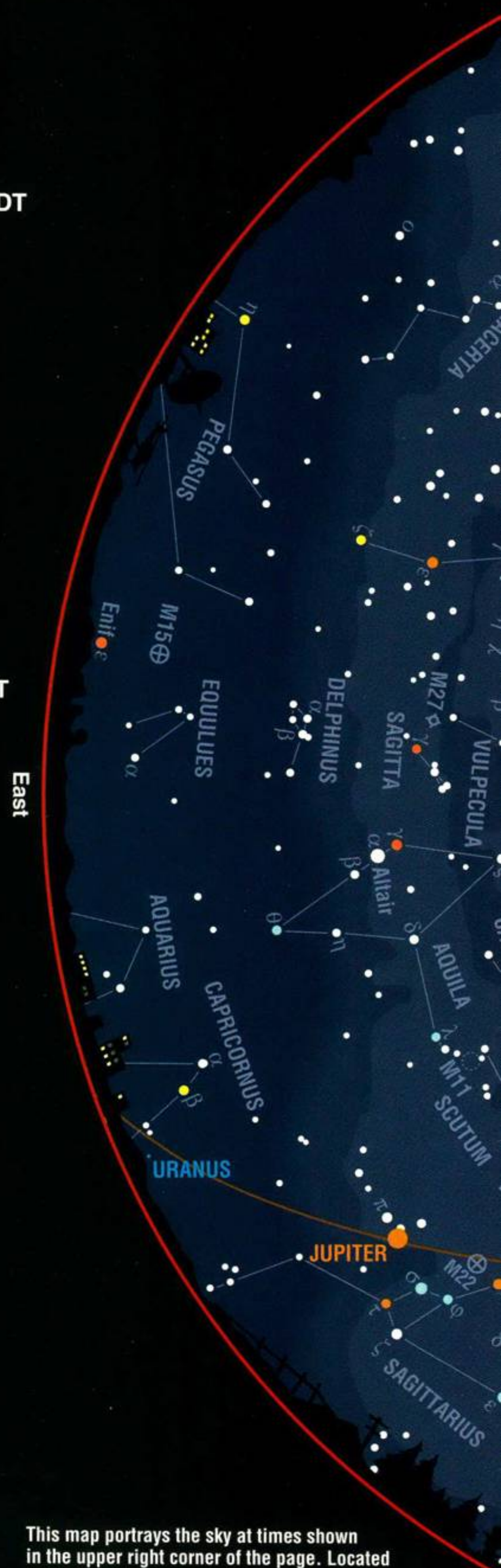
28 Asteroid Metis is at opposition

29 Venus passes 4° south of Mars, midnight EDT

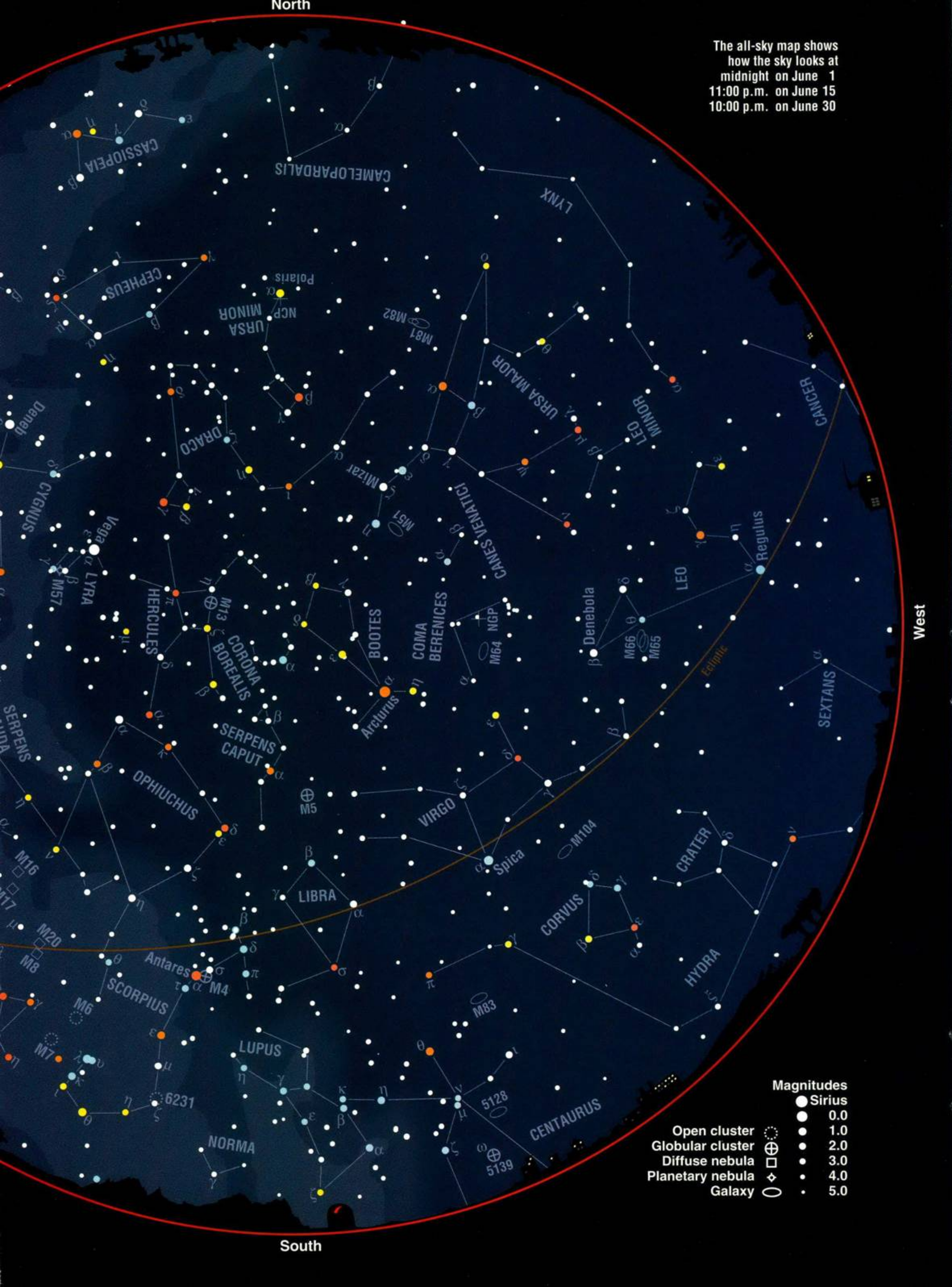
30 Full Moon is at 11:58 p.m. EDT (page 59)



Sun.	Mon.	Tue.	Wed.	Thu.	Fri.	Sat.
30						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29


East
LACERTA
PEGASUS
Enif
M15
EQUULEUS
DELPHINUS
SAGITTA
M27
VULPECULA
Altair
AQUILA
AQUARIUS
CAPRICORNUS
M11
SCUTUM
URANUS
JUPITER
M22
SAGITTARIUS

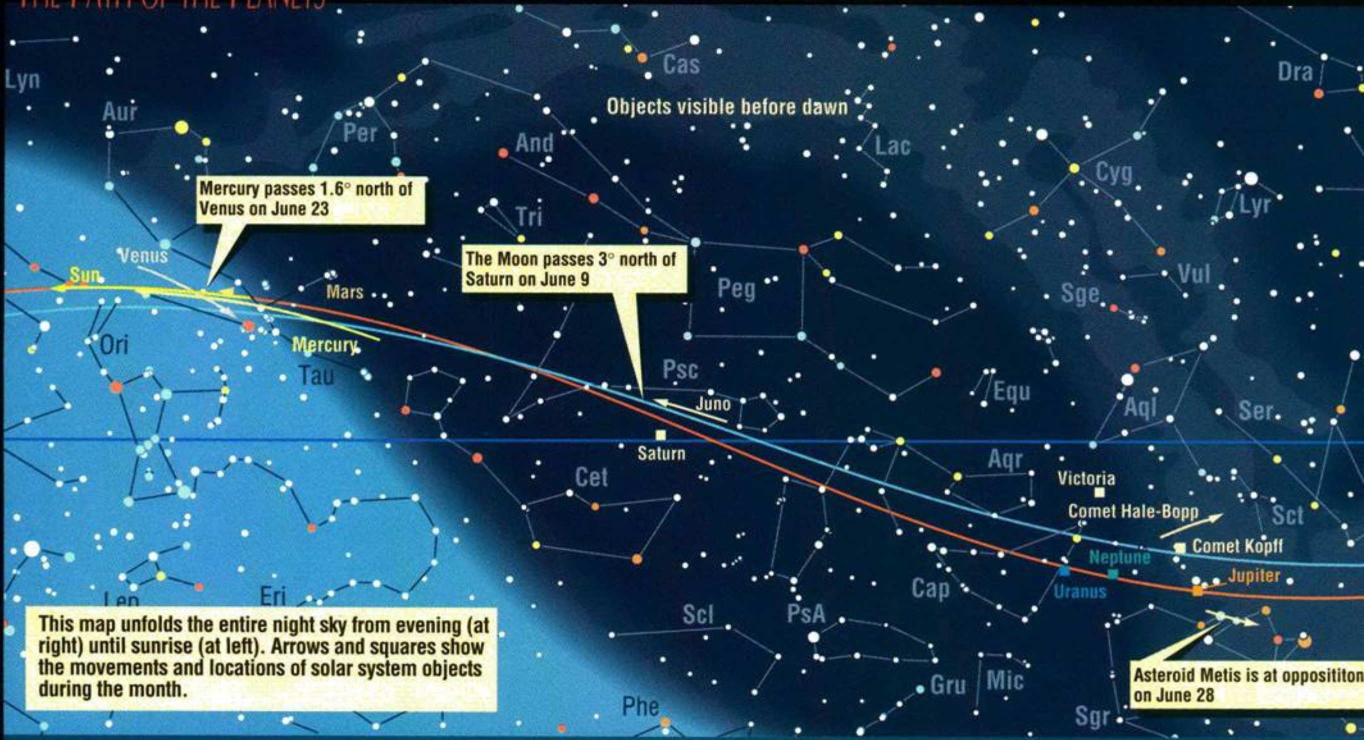
This map portrays the sky at times shown in the upper right corner of the page. Located just outside the map are the four directions: north, south, east, and west. To find stars above your horizon, hold the map overhead and orient it so a direction label matches the direction you're facing. The stars above the map's horizon now match what's in the sky.



North
South
West
CASSIOPEIA
CAMELOPARDALIS
LYNX
CEPHEUS
Polaris
NCP
URSA MINOR
M81
M82
URSA MAJOR
LEO MINOR
CANCER
Deneb
DRACO
Mizar
M51
CANES VENATICI
CYGNUS
Vega
LYRA
M57
HERCULES
M13
CORONA BOREALIS
BOOTES
COMA BERENICES
NGP
M64
Denebola
M66
M65
LEO
Regulus
Ecliptic
Arcturus
SERPENS CAPUT
SERPENS CAUDA
OPHIUCHUS
SEXTANS
M5
VIRGO
M104
Spica
CRATER
LIBRA
CORVUS
M16
M17
M20
M8
Antares
M4
SCORPIUS
M6
M7
HYDRA
M83
LUPUS
6231
5128
CENTAURUS
NORMA
5139
Magnitudes
Sirius
0.0
1.0
2.0
3.0
4.0
5.0
Open cluster
Globular cluster
Diffuse nebula
Planetary nebula
Galaxy

The all-sky map shows
how the sky looks at
midnight on June 1
11:00 p.m. on June 15
10:00 p.m. on June 30

THE PATH OF THE PLANETS



Lyn
Aur
Per
Cas
And
Tri
Lac
Cyg
Dra
Lyr
Vul
Sge
Peg
Psc
Juno
Saturn
Cet
Equ
Aqr
Aql
Ser
Sct
Victoria
Comet Hale-Bopp
Comet Kopff
Neptune
Uranus
Jupiter
Cap
PsA
Scl
Gru
Mic
Sgr
Phe
Eri
Leo
Ori
Tau
Sun
Venus
Mars
Mercury

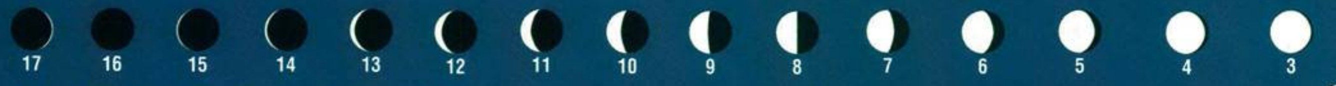
Objects visible before dawn

Mercury passes 1.6° north of Venus on June 23

The Moon passes 3° north of Saturn on June 9

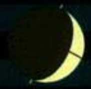
Asteroid Metis is at opposititon on June 28

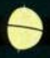
This map unfolds the entire night sky from evening (at right) until sunrise (at left). Arrows and squares show the movements and locations of solar system objects during the month.

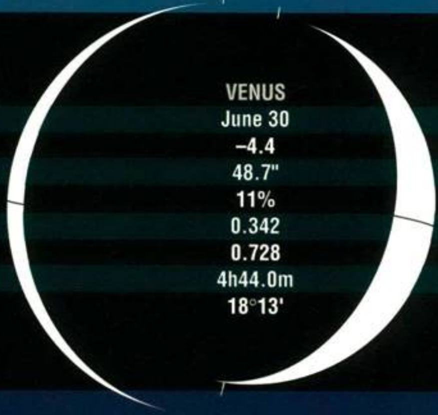


17
16
15
14
13
12
11
10
9
8
7
6
5
4
3

To locate the Moon in the sky, draw a line from the phase shown for the day straight up to the curved light-blue line.



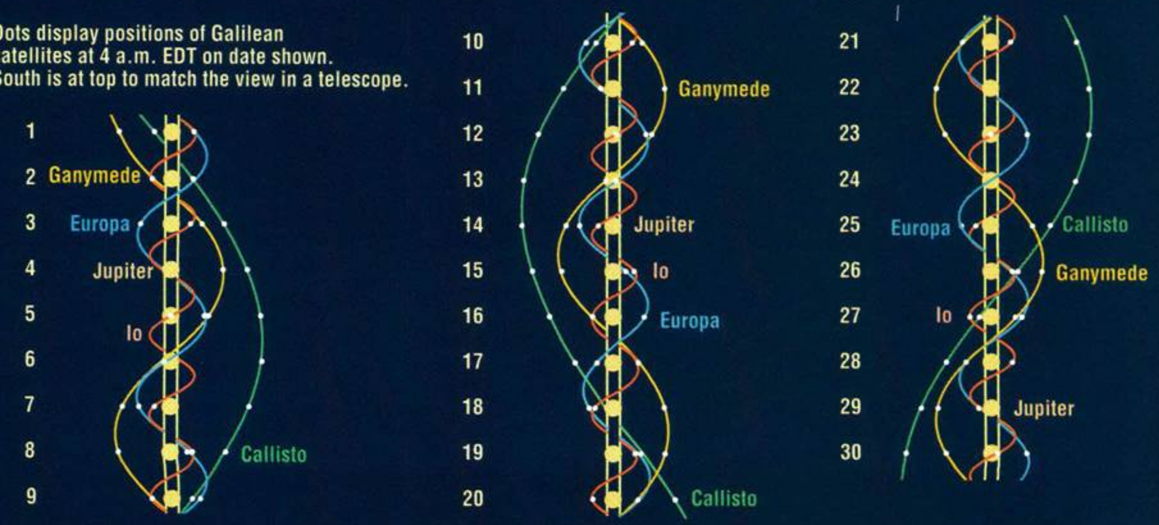


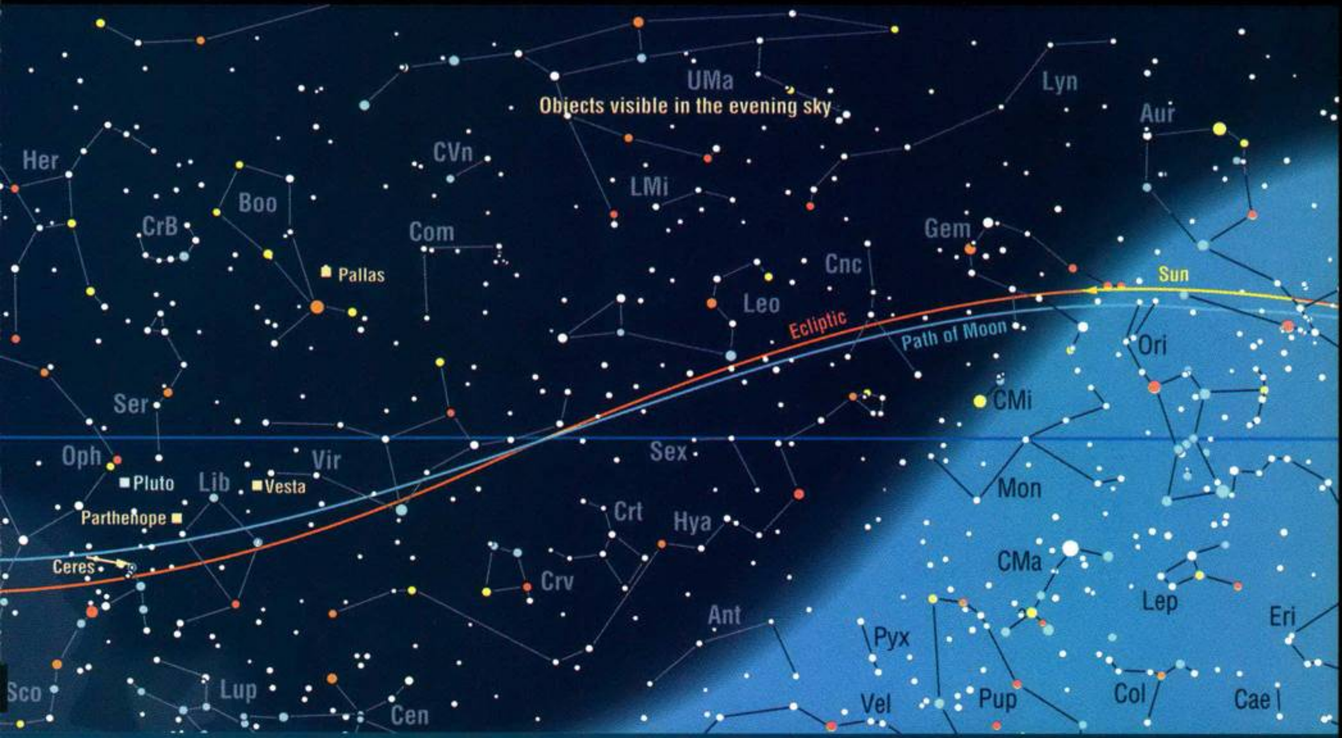


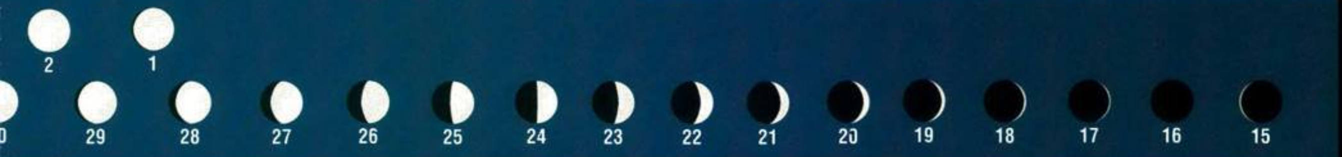
PLANETS	MERCURY	MERCURY	VENUS	VENUS	MARS
Date	June 1	June 30	June 1	June 30	June 15
Magnitude	1.6	–1.1	–4.1	–4.4	1.4
Angular Size	10.1"	5.6"	55.1"	48.7"	4.0"
Illumination	19%	84%	3%	11%	98%
Distance (AU) from Earth	0.668	1.210	0.303	0.342	2.351
Distance (AU) from Sun	0.456	0.319	0.725	0.728	1.464
Right Ascension (2000.0)	3h15.9m	5h40.0m	5h40.6m	4h44.0m	3h58.7m
Declination (2000.0)	14°08'	23°04'	25°03'	18°13'	20°27'

JUPITER'S MOONS

Dots display positions of Galilean satellites at 4 a.m. EDT on date shown. South is at top to match the view in a telescope.




Objects visible in the evening sky
UMa
Lyn
Aur
Her
CVn
LMi
CrB
Boo
Com
Gem
Pallas
Cnc
Sun
Leo
Ecliptic
Path of Moon
Ori
CMi
Ser
Sex
Oph
Vir
Pluto
Lib
Vesta
Mon
Parthenope
Crt
Hya
Ceres
Crv
CMa
Lep
Ant
Eri
Pyx
Sco
Lup
Cen
Vel
Pup
Col
Cae


2
1
29
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25
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22
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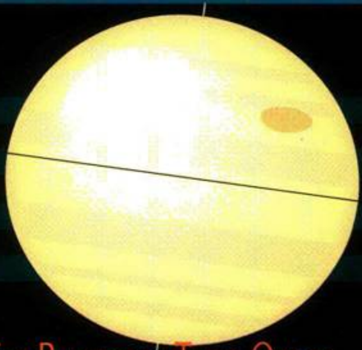
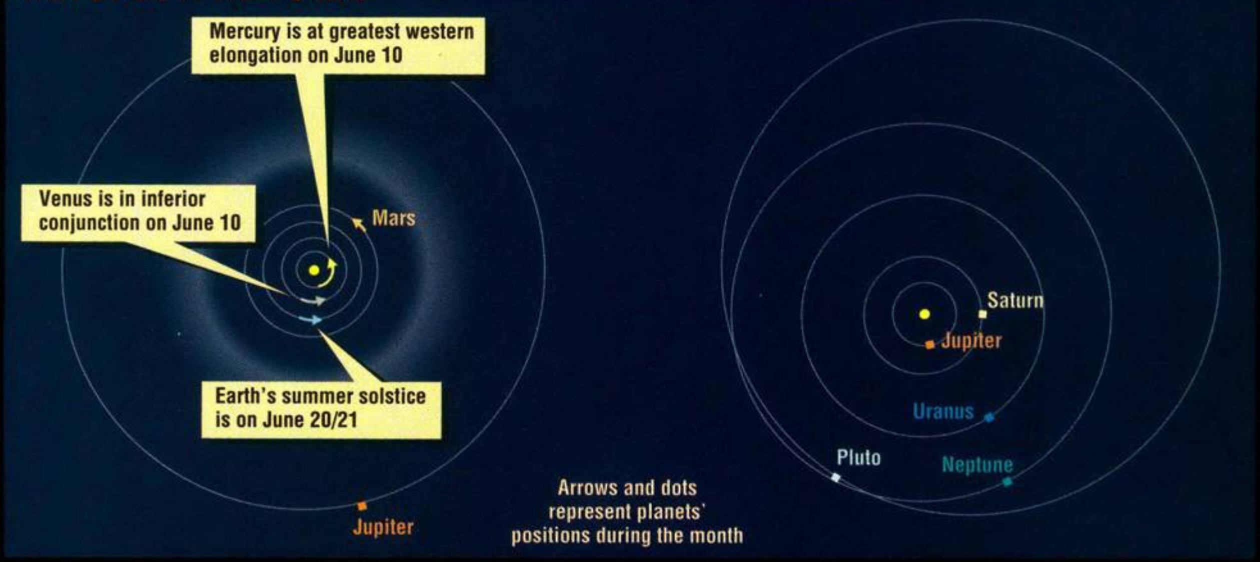
19
18
17
16
15



JUPITER	SATURN	URANUS	NEPTUNE	PLUTO
June 15	June 15	June 15	June 15	June 15
–2.7	0.9	5.7	7.9	13.7
46.4"	17.1"	3.7"	2.3"	0.1"
100%	100%	100%	100%	100%
4.249	9.693	18.979	29.305	28.995
5.210	9.529	19.770	30.161	29.908
19h06.0m	0h27.4m	20h26.3m	19h56.9m	16h07.1m
–22°36'	0°31'	–19°49'	–20°14'	–7°16'

THE PLANETS IN THEIR ORBITS


Mars
Jupiter
Saturn
Jupiter
Uranus
Pluto
Neptune

Mercury is at greatest western elongation on June 10

Venus is in inferior conjunction on June 10

Earth's summer solstice is on June 20/21

Arrows and dots represent planets' positions during the month magnitude stars that are easily visible in a small scope at high power.

Northwest of Gemini lies dazzling Capella in Auriga the Charioteer, scintillating like a wind-blown candle flame. At magnitude 0.08, Capella ranks as the brightest star in this corner of the sky. In this case, however, brightness does not denote nearness. Of the four stars mentioned, Procyon is the nearest at a mere 11 light-years, while Capella lies 42 light-years away.

Overhead, the stars of spring appear reluctant to shuffle off the seasonal stage, even with the summer solstice (June 20, 10:24 p.m. EDT) bearing down on them. By month's end, however, this diffidence will be overcome as Leo decisively begins its long, head-first dive toward the west, with Virgo trailing after. But early in the month, Spica doesn't even cross the north-south line dividing the sky (the meridian) until nearly 10 o'clock. Above and to the left of Spica beams orange Arcturus, brightest star in the northern night sky. It is outshone only by Sirius, Canopus, and Alpha Centauri in all the nocturnal heavens. To the north-northeast extends its kite-shaped grouping, Boötes the Herdsman.

At least two other planets lie in the evening sky, though they are invisible to all but sensitive professional instruments. And even then, they can only be "seen" indirectly by their subtle gravitational tugs on their parent stars' apron strings. The 5th-magnitude Sun-like star 70 Virginis, which lies about halfway between Eta (η) Boötis and Epsilon (ε) Virginis, harbors a planet more massive than six Jupiters.

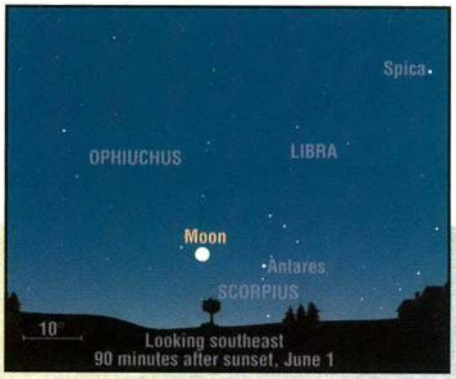
And in Ursa Major, the

First Views:
A Blue Moon for June

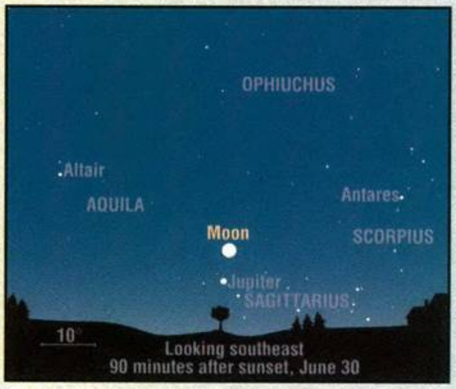
We humans tend to exaggerate how seldom events in our lives occur. Proud men tell their mates, "Why, I get lost once in a Blue Moon," implying that "once in a Blue Moon" means never or, at most, once in a lifetime. For the record, guys, Blue Moons happen more often than you think.

Astronomically, a Blue Moon is the second of two Full Moons that fall in the same month. That can happen because a Full Moon occurs every 29.531 days. Divide the number of days in a tropical year, 365.242, by 29.531 and you get 12.368 Full Moons in a year. This means that Blue Moons come, on average, once every 2.72 years, or 2 years plus 7, 8, 9, or 10 months.

Blue Moons don't occur regularly because our calendar isn't regular. February has 28 days (29 in a Leap Year), April, June, September, and November have 30, and the other seven months have 31 days. Furthermore, the exact day a Blue Moon falls on depends on the time zone in which you live. For example, the second Full Moon in June occurs at 11:58 p.m. EDT on the 30th. However, if you reckon time using Universal Time, it will already be 3:38 a.m. on July 1 when the Moon becomes full. So from the standpoint of Universal Time, the Blue Moon occurs in July (July's other Full Moon comes on the morning of July 30). — *Rick Shaffer*



Looking southeast
90 minutes after sunset, June 1

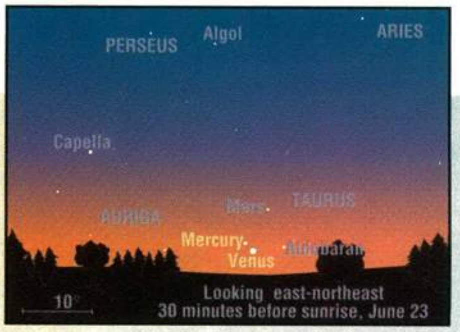


Looking southeast
90 minutes after sunset, June 30

Venus in the Morning

June marks the end of Venus' eight-month reign as the evening star. Look for it low in the west-northwest during the first few days of the month. On the 1st, Venus stands 5° above the horizon 30 minutes after sunset. It should be an easy naked-eye target unless your horizon's hazy, in which case you'll want to use binoculars. Look a little less than one binocular field above where the Sun set to find Venus through the haze.

Venus reaches inferior conjunction with the Sun on June 10, after which it becomes a morning object. It then remains visible in the morning sky through the end of the year. Start looking for the morning star as early as June 17 or 18, very low in the east-northeast 20 minutes before sunrise. Even though Venus blazes at magnitude −4.0, you will probably need binoculars and an unobstructed horizon to see it.



Looking east-northeast
30 minutes before sunrise, June 23

The best aspect of Venus' emergence into the morning twilight comes on June 23, when Mercury passes only 1.6° from Venus. Again, use binoculars to find the duo low in the east-northeast about 30 minutes before sunrise. Venus shines at magnitude −4.2, so you'll likely find it before the −0.5-magnitude Mercury. Shift your view about 6° higher to find much dimmer Mars; 5° to the right of Venus lies Aldebaran and the V-shaped Hyades star cluster. — *R.S.*

Clash of the Comets in Sagittarius

During June, Sagittarius offers skywatchers two comets of similar brightness and appearance. But looks can be deceiving. Comet Kopff brightens from about magnitude 7.5 to 7.0 in anticipation of its closest approach to the Sun next month. Comet Hale-Bopp also brightens, from 7th to 6th magnitude, but its perihelion lies a full ten months away, in April 1997.

What's more, Hale-Bopp lies five times farther from Earth than Kopff. The only clue that Kopff lies closer comes from the slight tail it might sprout as June draws to a close. Distant Hale-Bopp probably won't sport much of a tail until this fall.

Both comets spend the month northeast of Sagittarius' Teapot. Brilliant Jupiter serves as a good signpost for locating them, lying roughly 7° and 10° from Kopff and Hale-Bopp, respectively. On June 11, Hale-Bopp's northwestward motion draws it within 3° of the slower moving Kopff, which is heading south and east. From then until the 16th, Kopff saunters through the coarse open cluster NGC 6774. And on June 29, it sweeps 4' from magnitude-3.9 Rho (ρ) Sagittarii.

As if biding its time, Hale-Bopp appulses nothing of note this month, other than passing 2.5° north of NGC 6774 on June 13. By that time the waning crescent Moon rises around 4 a.m. and both comets should be easy to follow using binoculars under a dark sky. — *R.S.*

COORDINATES FOR COMET KOPFF*

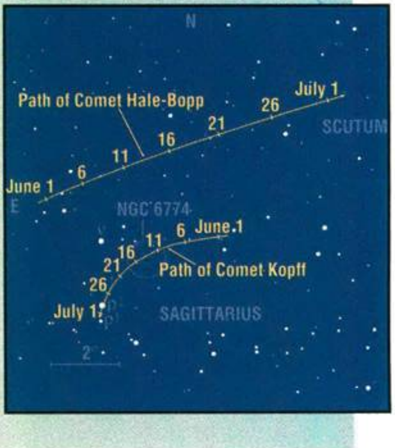
Date	R.A.	(2000)	Dec.
June 1	19h07.6m		−15°51'
June 6	19h11.6m		−16°00'
June 11	19h14.9m		−16°15'
June 16	19h17.6m		−16°34'
June 21	19h19.5m		−17°00'
June 26	19h20.9m		−17°30'
July1	19h21.9m		−18°05'

*Positions given for 4 a.m. EDT

COORDINATES FOR COMET HALE-BOPP*

Date	R.A.	(2000)	Dec.
June 1	19h28.4m		−14°43'
June 6	19h23.9m		−14°16'
June 11	19h18.9m		−13°48'
June 16	19h13.4m		−13°20'
June 21	19h07.5m		−12°51'
June 26	19h01.1m		−12°21'
July 1	18h54.3m		−11°52'

*Positions given for 4 a.m. EDT



Ceres Introduces a Double

Scorpius is so loaded with wonderful targets that some worthwhile objects get lost in the shuffle. So it is with the beautiful double Beta (β) Scorpii, one of the bright stars that mark the Scorpion's head and shoulders, just north and west of Antares. It takes a close approach from the 7th-magnitude asteroid Ceres toward the end of June to remind us that Beta, called Graffias by the ancients, is worth viewing.

Graffias A is a magnitude-2.6 star of spectral type B0. It's one of those hot, massive stars that lives life in the stellar fast lane, more than one thousand times as luminous as our Sun. Recent studies show it to have a smaller companion in a 6.8-day orbit. Another close companion, 10th-magnitude Graffias B, requires a large telescope and superb seeing to be discerned.

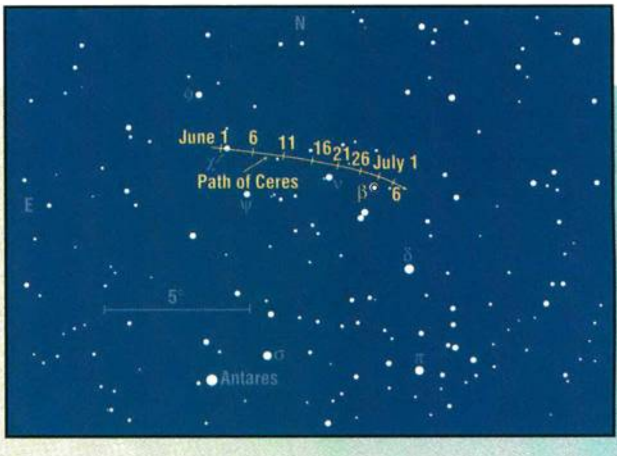
Graffias has still a fourth companion, visible in even a modest backyard scope: magnitude-4.9 Graffias C, which lies 13.7" northeast of A. Studies of Graffias C reveal that it, too, has a very close companion. This makes the Beta Scorpii system a quintet, even though amateur telescopes show it only as a double.

Beginning the last week of June, watch Ceres close in from the northeast to within 24' of Graffias on July 1. Viewing the approach is quite easy, even in binoculars. And you can document the *asteroid's nightly motion* photographically or with electronic imaging. — *R.S.*

COORDINATES FOR CERES*

Date	R.A.	(2000)	Dec.
June 1	16h27.9m		−18°28'
June 6	16h23.2m		−18°36'
June 11	16h18.7m		−18°45'
June 16	16h14.5m		−18°54'
June 21	16h10.7m		−19°04'
June 26	16h07.4m		−19°15'
July 1	16h04.7m		−19°26'
July 6	16h02.6m		−19°39'

*Positions given for 11 p.m. EDT

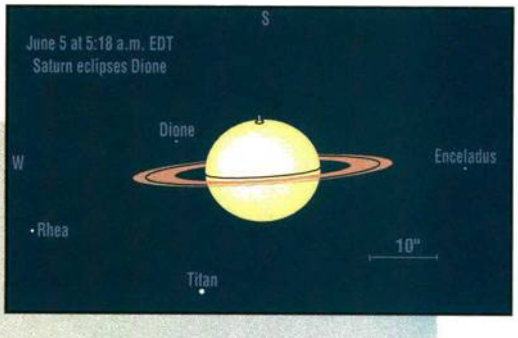


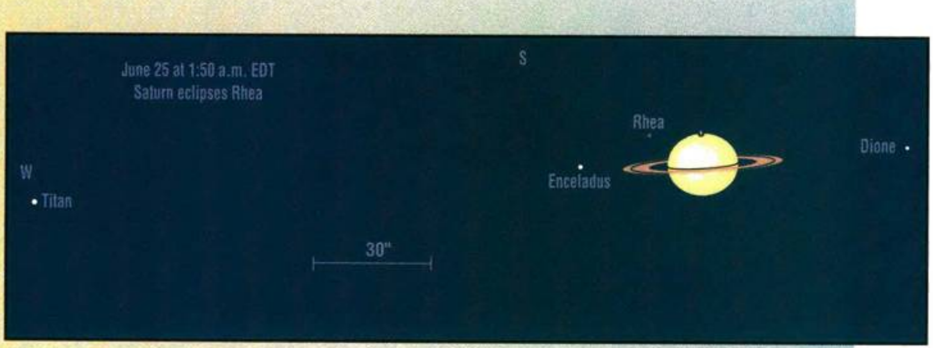
Observer's Challenge:
Saturn's Disappearing Moons

On February 11/12, Earth passed though the plane of Saturn's rings for the third time in a year, and the last time until the summer of 2009. Now, with Earth moving farther south in Saturn's sky, the ringed planet continues to eclipse its satellites at a regular, though somewhat diminished rate.

June features five such eclipses for observers in North America. Only Dione and Rhea are involved, and the geometry of the Sun, Earth, and Saturn allows us to witness only the satellites' disappearances. Each moon darkens as it moves into Saturn's shadow and then brightens a few minutes later as its orbital motion carries it out of the ringed planet's umbra. The longest eclipse lasts just 3.8 minutes, so being prepared is crucial to witnessing these elusive events. Set up your telescope to view Saturn no less than a half hour before the eclipse begins. And use the eyepiece renderings to be sure you're looking at the right satellite before it enters the planet's shadow.

Those of you with access to a very sensitive video camera might try recording the eclipses for replay at a club meeting. If you own a CCD imager that can take a series of short exposures, try doing CCD photometry on the disappearing satellite to see what your light curve reveals. — *R.S.*


June 5 at 5:18 a.m. EDT
Saturn eclipses Dione


June 25 at 1:50 a.m. EDT
Saturn eclipses Rhea

EVENTS OF THE SATURNIAN SATELLITES

Date	Begin Time	End Time	Event	Type of Event	Distance
June 5	9h16.9m	9h19.0m	Saturn eclipses Dione	Disappearance	1.6
June 16	4h51.4m	4h55.1m	Saturn eclipses Rhea	Disappearance	1.9
June 16	8h04.5m	8h06.5m	Saturn eclipses Dione	Disappearance	1.6
June 25	5h47.3m	5h51.1m	Saturn eclipses Rhea	Disappearance	1.9
June 27	6h52.0m	6h54.1m	Saturn eclipses Dione	Disappearance	1.6

Begin Time: Universal Time at the beginning of the event. (Subtract 4 hours to convert to EDT, 5 hours for CDT, 6 hours for MDT, and 7 hours for PDT.) **End Time:** Universal Time at the end of the event. **Event:** The nature of the event and the objects involved. **Type of event:** Whether the event is a disappearance or reappearance. **Distance:** The apparent distance of the satellite from Saturn's center expressed in Saturnian equatorial radii.

5th-magnitude star 47 Ursae Majoris is home to a planet at least 2.3 times Jupiter's mass. This star, also similar in class to the Sun, lies a little over 4° south-southwest of 3rd-magnitude Psi (ψ) Ursae Majoris. Follow the Dipper's pointer stars in the direction opposite that of the North Star to lead you to 47 UMa.

Farther east we finally enter the domain of the summer sky. Leading the way is the constellation Hercules, son of Zeus. At 10 p.m. look for his distinctive, trapezoidal "keystone" asterism about 50° above the eastern horizon. Once you find this asterism, you can easily pick out the rest of the constellation: his upper torso stretching to the south, his legs nearly touching the northern circumpolar groups. If you have a telescope, aim it just to the right of Eta (η) Herculis, the northwestern star in the keystone. That cottony spot of light you see is the glow of a million stars making up globular cluster M13, one of the finest deep-sky objects in the northern sky.

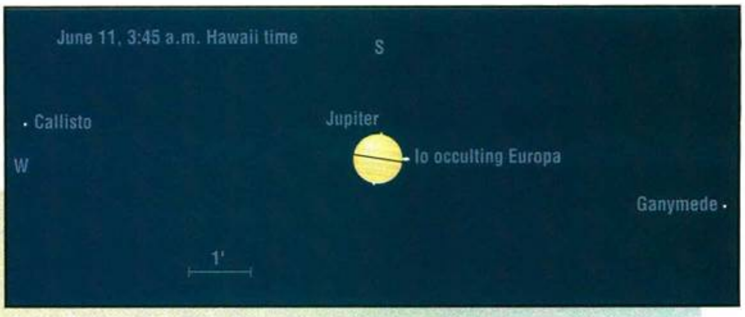
Floating serenely above the eastern horizon now are the hallmark stars of summer: The brightest one, Vega in Lyra the Lyre, precedes Deneb in Cygnus the Swan and Altair in Aquila the Eagle. Running through these groups is the summer Milky Way. Follow its chalky white path south into Scorpius, which by 11 p.m. lies mostly above the horizon. Not far behind is Sagittarius with our first bright

View the Jovian Satellite Action

In much the same way we've seen recently with Saturn, Earth occasionally passes through the orbital plane of Jupiter's satellites. When this happens, once every six years, we see the Galilean satellites mutually eclipse and occult one another. In an eclipse, a moon passes through the shadow of another. In an occultation, one moon passes in front of another as seen from Earth. Although activity like this is sparse for 1996, it picks up in 1997 before trickling off in 1998. In other words, we're just coming into a season of Jovian satellite mutual events.

Mutual events on June 4, 11, and 18 are best seen from the Central Pacific, including Hawaii, Australia and New Zealand, most of Southeast Asia, Eastern China, and on into Korea and Japan. Europe, Africa, and South America are best situated to see the events on June 8, 15, and 22. Those living on the east coast of North America can see June 15's second event, as well as the one on June 22, albeit Jupiter lies near the horizon for both.

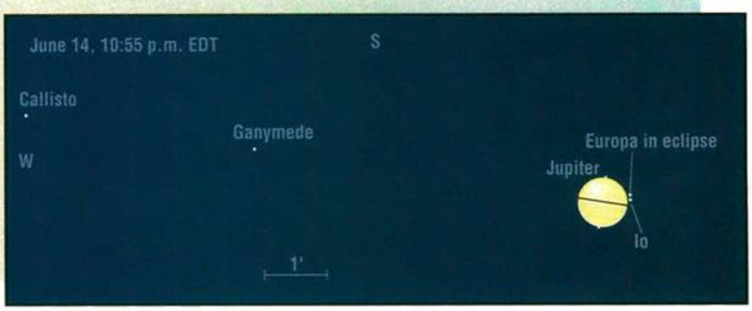
Occultations are the most obvious to glean. In poor to average seeing, the satellites appear to merge into one, only to separate minutes later. In good seeing, the satellites become noticeably elongated as they merge. Eclipses at this early stage of the season are likely to be subtle, possibly so subtle that they will only be detectable using some sort of photometry. Those with CCD cameras and software that allows photometry might find this worthwhile. — *R.S.*



EVENTS OF THE JOVIAN SATELLITES

Date	Begin Time	End Time	Event	Type of Event
June 4	14h20.5m	14h41.7m	Io occults Europa	Partial
June 8	1h48.5m	2h08.3m	Io occults Europa	Partial
June 11	13h36.9m	13h54.1m	Io occults Europa	Partial
June 15	1h27.5m	1h41.3m	Io occults Europa	Partial
June 15	2h50.1m	3h03.8m	Io eclipses Europa	Penumbral
June 18	13h22.0m	13h27.9m	Io occults Europa	Partial
June 18	14h27.3m	14h38.5m	Io eclipses Europa	Penumbral
June 22	2h05.3m	2h05.3m	Io eclipses Europa	Grazing

Begin Time: Universal Time at the beginning of the event. (Subtract 4 hours to convert to EDT, 5 hours for CDT, 6 hours for MDT, and 7 hours for PDT.) **End Time:** Universal Time at the end of the event. **Event:** The nature of the event and the objects involved. **Type of event:** Whether the event is partial, penumbral, or grazing.



planet of the late evening, **Jupiter**. Early in the month, Jupiter clears the horizon a little before 11 p.m., but you won't see it until it climbs above the trees, probably an hour or so later. Next month, on July 4, Jupiter comes to opposition, when it rises at sunset and remains visible all night.

Trailing just behind Jupiter are two outer planets, **Uranus** and **Neptune**. Both lie a little west of the "smile in the sky," as Capricornus the Sea Goat is sometimes referred to, with Neptune just over the border in eastern Sagittarius. Binoculars allow you to easily pick out Uranus as a point of greenish light among the starry backdrop of the region. Neptune, however, provides more of a challenge. Although you can spot it with binoculars, you won't be able to see its blue-green color unless you use a telescope.

Rising a couple of hours after midnight, and still three months away from opposition, is **Saturn**. The viewing window at the beginning of the month is narrow — between about 3 a.m. local time and dawn. Conditions improve slightly by June 30, when Saturn rises at about 1 a.m. among the background stars of Cetus. Although not considered a zodiacal constellation, Cetus becomes one by proxy when a planet cuts through the constellation south of the ecliptic line, as Saturn is doing now.

Displayed in all its glory above Saturn in the morning sky is Pegasus the Winged Horse and its central anchor of four stars, the Great Square. The horse's nose, denoted by the star Enif, stretches to the west, where it almost nuzzles against Equuleus the Lesser Horse, a faint and insignificant constellation of five main stars. Only diehard constellation lovers will be able to spot this group, whose brightest member shines at only 4th magnitude. Look for it with binoculars between Enif and the tadpole-like constellation, Delphinus the Dolphin.

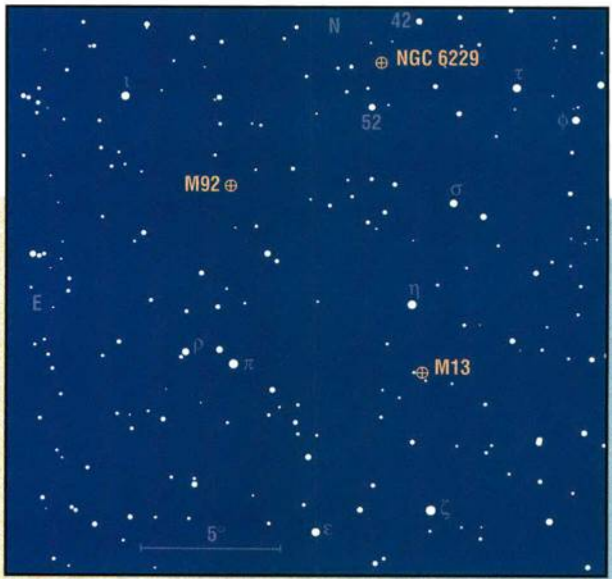
The creator of Equuleus, the second-smallest constellation in the sky, is unknown, although it appears on Ptolemy's original list of 48 constellations compiled in the second century. Ian Ridpath, in his book *Star Tales*, suggests that Ptolemy may have had the little horse in mind in the story of Hippe, daughter of Chiron the centaur. Hippe was seduced by Aeolus, Greek god of the wind. To hide her pregnancy from her father she fled to the mountains, where she eventually gave birth to Melanippe. When Chiron came looking for her, Hippe implored the gods to hide her. They obliged by changing her into a mare and placing her among the stars where she hides still, with only her head showing.

To the northeast, scrutinize the region between Alpha (α) and Beta (β) Pegasi for 5th-magnitude 51 Pegasi, home star to yet a third extrasolar planet of Jovian size.

The final two planets in our solar system, Mars and Mercury, rise about an hour before the Sun. First-magnitude **Mars** is climbing slowly out of the twilight glare and can be glimpsed about 5° directly above brilliant Venus on June 25 and 26. Meanwhile **Mercury** puts in its worst morning apparition of the year for Northern Hemisphere observers. At greatest elongation on June 10, it lies just 6° high in the east-northeast, below and to the right of slightly fainter Mars. ☐

Jeff Kanipe is Astronomy's *managing editor. Rick Shaffer is an engineer and writer living in Arizona.*

The Globulars of Hercules



June evenings bring into view one of the sky's premier globular clusters, M13. On dark nights away from city lights, M13 can be glimpsed with the naked eye as a 5.9-magnitude fuzzy object 17' wide. Nestled on the western side of Hercules' torso, you can find it about a third of the way from Eta (η) to Zeta (ζ) Herculis.

M13 is one of over 150 known clusters of ancient stars orbiting in the halo of our galaxy. Despite a huge distance of 24,000 light-years, it ranks among the most awe-inspiring objects in the sky. Astronomers estimate M13 contains nearly a million stars within a sphere 100 light-years across. We see a thousand of the brightest stars, the most luminous being 11th-magnitude red giants.

A 6-inch telescope at high power starts to resolve stars along the cluster's edge. In much larger instruments, like a 20-inch Newtonian, the cluster takes on a 3-D look, crisscrossed by dark lanes the mind constructs when confronted by so many stars.

Although this great globular gets most of the attention, Hercules harbors two other stunning examples. M92 would be well-known if it were located far from M13. It's almost as big and rich as M13, but lies about 2,000 light-years farther away so it appears fainter at magnitude 6.5. A telescope reveals that M92 has a far tighter core than M13.

NGC 6229, a looser, dimmer cluster glowing at magnitude 9.4, rounds out the Hercules' globulars. A large telescope at high power shows it as a smattering of stars shining from 100,000 light-years away. — *R.S.*

T. L. Dessert

Bill and Sally Fletcher

Bill Iburg

Jupiter's Magnificent Show

The year's best viewing of detail-rich Jupiter comes during the short nights of June and July.

by Richard Talcott

It hasn't been Jupiter's decade. First, in the summer of 1994, Comet Shoemaker-Levy 9 smashed into the planet, leaving unsightly scars that lasted for months. Then in December 1995, the much smaller Galileo spaceprobe pierced its outer layers, relaying information about the planet's atmosphere to scientists back on Earth.

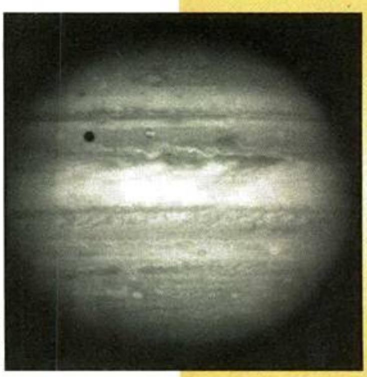
The bombardment of Jupiter now appears to be over, at least for the time being, but the scrutiny goes on. The Galileo orbiter will monitor the planet and its satellites from up close for the next two years. Meanwhile back on Earth, thousands will turn their telescopes toward Jupiter to get their own look at a planet that is slowly giving up its secrets.

You can be among those multitudes, viewing a complex atmosphere featuring huge storms that rage for decades, even centuries, and watching the dance of the Jovian satellites as they orbit the planet. Jupiter appears at its best when it is closest to Earth during June and July, the two months surrounding its opposition on July 4.

You don't need a large telescope to enjoy viewing the giant planet. Even a 2- or 3-inch scope reveals the most prominent atmospheric bands and four large moons. Named Io, Europa, Ganymede, and Callisto in order of increasing distance from Jupiter, these Galilean satellites display a number of interesting phenomena as they circle Jupiter. A 4-inch telescope shows changes in the clouds at the top of the planet's atmosphere, and larger scopes will reveal more detail as well as smaller features when Earthly conditions allow.

Earth's atmosphere often limits an observer's ability to see fine detail on Jupiter. Turbulence caused by the air's motion produces blurry images in the eyepiece. This poor "seeing" poses a greater problem the lower Jupiter lies in the sky because the planet's light must pass through more of the atmosphere. Unfortunately, Jupiter now lies in the southern constellation of Sagittarius, so an observer at 40° north latitude sees it no more than about 30° above the horizon. The best time to observe it during June and July comes around midnight, when it lies highest in the south.

You can reduce the problem of air turbulence by pointing your telescope over terrain that keeps a fairly constant temperature during the course of a day. A large expanse of grass, like you might find at a park or golf course, or large body of water works well. Avoid setting up near buildings, paved parking lots, or other surfaces that absorb heat during the day and release it at night.

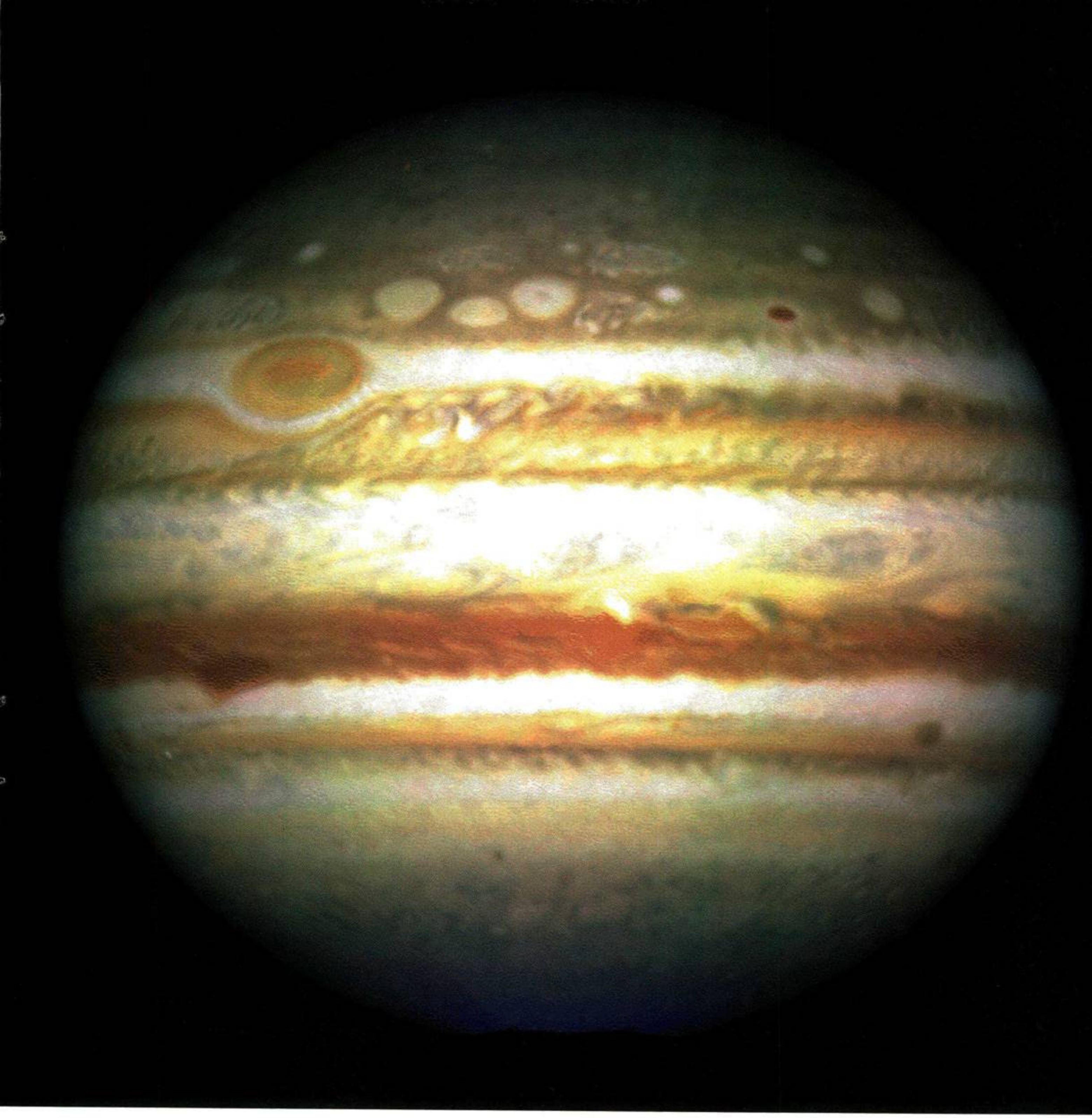


NASA/HST

Whither Galileo?

While Earthbound observers scan Jupiter from afar, the Galileo spacecraft will be scrutinizing the giant planet and its satellites. Over the next year and a half, Galileo will make several close passages by the outer three Galilean satellites — Europa, Ganymede, and Callisto — as well as monitor the volcanically active inner moon Io and Jupiter itself from a greater distance.

Date	Satellite	Closest approach
June 27, 1996	Ganymede	980 km
September 6, 1996	Ganymede	255 km
November 4, 1996	Callisto	1,110 km
December 19, 1996	Europa	695 km
February 20, 1997	Europa	588 km
April 5, 1997	Ganymede	3,065 km
May 7, 1997	Ganymede	1,584 km
June 25, 1997	Callisto	416 km
September 17, 1997	Callisto	524 km
November 6, 1997	Europa	1,119 km



NASA/HST

JUPITER APPEARS in all its glory through the Hubble Space Telescope, but observers with modest telescopes can view most of the same features.

In the end, however, the key factor in detecting detail is the observer's skill. Don't expect to see a wealth of detail the very first time you view Jupiter — that requires experience. But if you start observing the planet well before opposition, by July you should be gleaning most of what it has to offer.

Begin observing with a low-power eyepiece. First off, that's all you need to get a good view of the Galilean satellites. In addition, Jupiter appears large enough, with a diameter of more than 45" throughout June and July, that you don' t need a lot of power to get a reasonably big image of it. If the seeing appears steady, try increasing the power to about 25x for each inch of aperture. If the image of Jupiter remains sharp at that magnification, you can bump it up a little more.

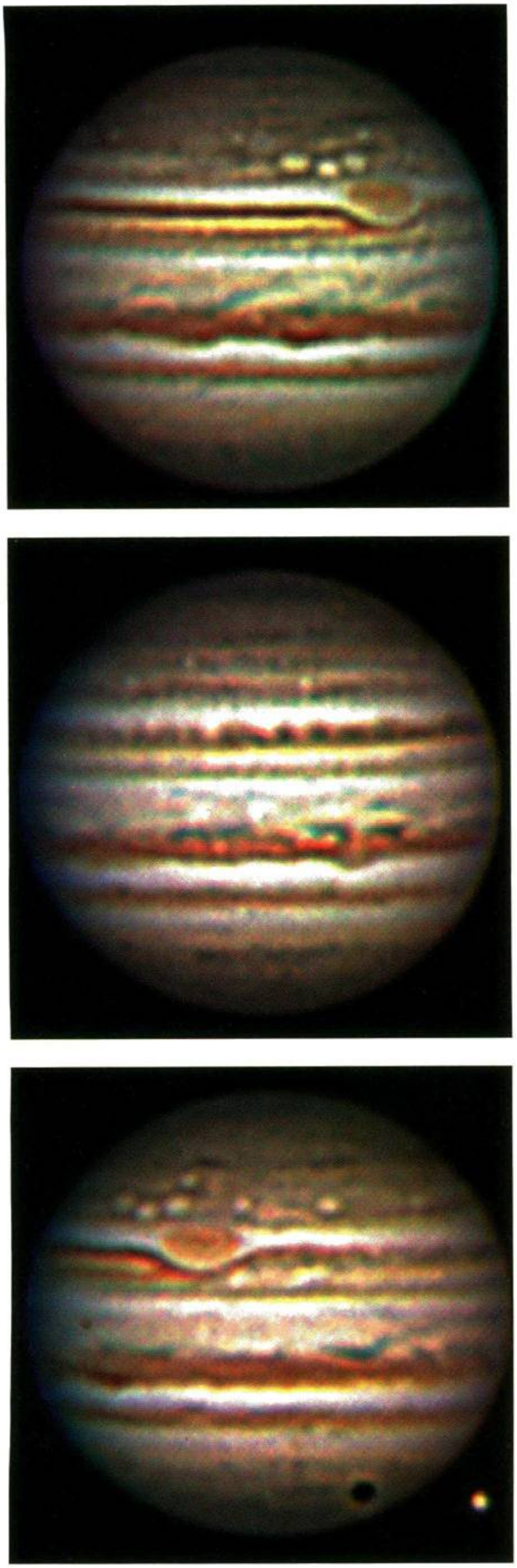
The first thing you'll likely notice is that Jupiter's disk appears flattened. In fact, its equatorial diameter measures 7 percent larger than its polar diameter. (At opposition in July it will appear 47.0" across its equator and 44.0" through the poles.) The bulge along the equator results from the planet's rapid rotation: It spins once on its axis in less that ten hours.

The next features you'll notice are the series of alternating light zones and dark belts that girdle the planet parallel to its equator. The zones are cool, high-pressure areas where bright clouds of ammonia ice crystals condense out of rising gases. The belts are warmer regions of low pressure where the top layer of clouds has evaporated and deeper layers become visible. Unfortunately, the Galileo spaceprobe apparently entered Jupiter in a relatively clear area, missing most of the top layer of ammonia clouds.

Even a well-constructed 2-inch telescope shows the North and South Equatorial Belts (NEB and SEB) lying equidistant from Jupiter's equator. They rarely look identical, at least to experienced observers, with the NEB usually more conspicuous. (The SEB has even disappeared on occasion, most recently in 1989-90, and came close to doing so again in 1992.) Of all the zones, the Equatorial Zone appears most obvious simply because it separates the two most prominent belts.

Larger telescopes or excellent seeing may be necessary to clearly distinguish the rest of the belts and zones. Moving away from the equator, the North and South Tropical Zones lie beyond the equatorial belts, with the North and South Temperate Belts next outward from them. These belts appear noticeably thinner and far less prominent than the equatorial belts. As you head closer to the poles, succeeding belts become faint and sometimes fragmented, showing up at some longitudes but not at others.

The belts and zones should only represent a starting point in your exploration of Jupiter. Many of the most interesting features in the Jovian cloudtops are those that form and decay over periods of weeks or months or those that change shape or color. Easily the most famous of these is the Great Red Spot. It's more than one hundred years old and perhaps several hundred — the Italian-French astronomer Giovanni Cassini reported seeing a spot in 1665 that astronomers think was the Red Spot. This enormous system of high pressure, some 20,000 miles long and 8,000 miles wide, lies nestled in the South Tropical Zone. Its reddish cloudtops, which range in color from brick red to pale salmon (in 1995 it tended toward salmon), are the coldest feature on



DONALD PARKER

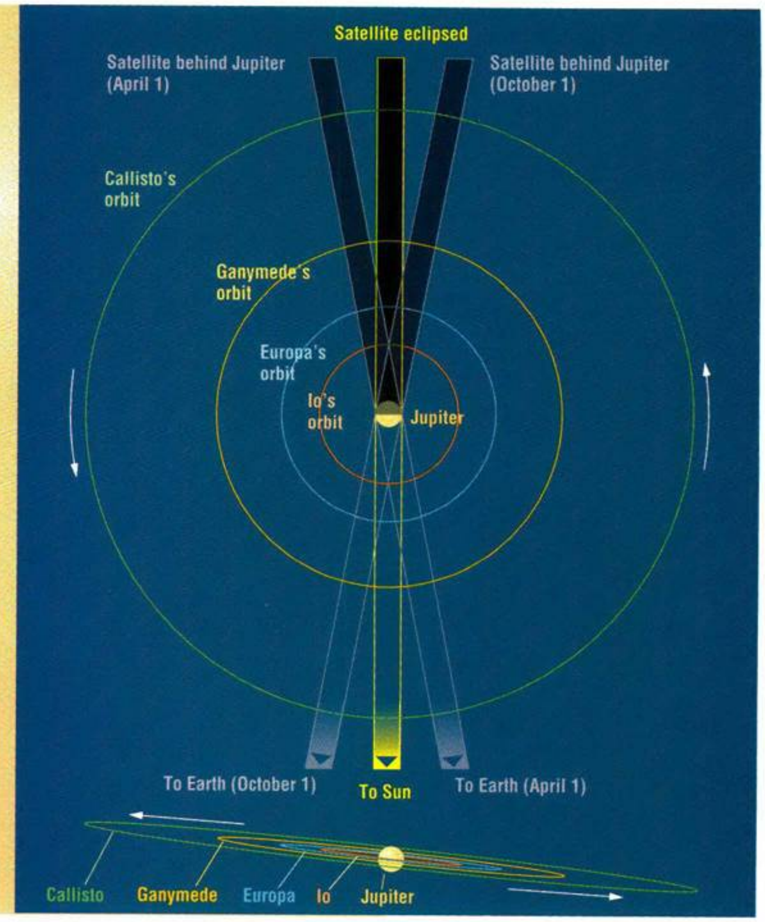
THE VIEW CHANGES constantly as Jupiter spins quickly on its axis.

Spotting the Galilean Satellites

Anyone with a telescope can view the four large moons of Jupiter as they revolve around the planet. In fact, they would be bright enough to glimpse with the naked eye if brilliant Jupiter were not so close, and steadily held binoculars can bring them into view.

The best time to observe them, however, comes when they are close to passing in front of or behind Jupiter. When a satellite passes in front, you can watch as both its disk and dark shadow transit the planet's cloudtops. When traveling behind, the satellite will both disappear behind the planet (an occultation) and be eclipsed by its shadow. The table spotlights a few of the better events visible from North America in June and July. In addition, this year the satellites begin to eclipse and occult one another for the first time in six years (see this month's Sky Almanac for details on these mutual events).

Date	Event	Time (EDT)
June 5	Io eclipse begins	11:27 p.m.
	Occultation ends	2:22 a.m.
June 12	Ganymede shadow enters	10:56 p.m.
	Transit begins	12:59 a.m.
	Shadow leaves	2:01 a.m.
	Transit ends	4:06 a.m.
June 13	Europa shadow enters	12:27 a.m.
	Transit begins	1:27 a.m.
	Shadow leaves	3:13 a.m.
	Transit ends	4:14 a.m.
June 17	Callisto eclipse begins	11:15 p.m.
	Eclipse ends	2:02 a.m.
	Occultation begins	2:51 a.m.
	Occultation ends	5:51 a.m.
July 8	Ganymede occultation begins	12:28 a.m.
	Eclipse ends	3:59 a.m.
July 12	Callisto transit begins	10:30 p.m.
	Shadow enters	12:30 a.m.
	Transit ends	1:25 a.m.
	Shadow leaves	3:31 a.m.
July 29	Io transit begins	10:23 p.m.
	Shadow enters	11:00 p.m.
	Transit ends	12:39 a.m.
	Shadow leaves	1:16 a.m.
July 30	Europa occultation begins	10:45 p.m.
	Eclipse ends	2:53 a.m.



ASTRONOMY/ Thomas L. Hunt

Jupiter and rotate counter-clockwise in a period of six days.

Although not as long-lived as the Great Red Spot, three white ovals have been observed continually since the 1940s. Located in the South Temperate Belt a little bit south of the Red Spot, these rotating cyclones show up easily in a 6-inch or larger scope.

Perhaps the most conspicuous of Jupiter's more transient features are the festoons. These dusky filaments are deep holes in the cloudtops that loop out from the edge of a belt into a zone and typically appear blue or blue-gray. Last year, several huge festoons curved into the Equatorial Zone from both the NEB and SEB. If these festoons persist, or new ones form, they should be easy to pick out with a 4-inch telescope, although beginners may have a hard time detecting their bluish tint.

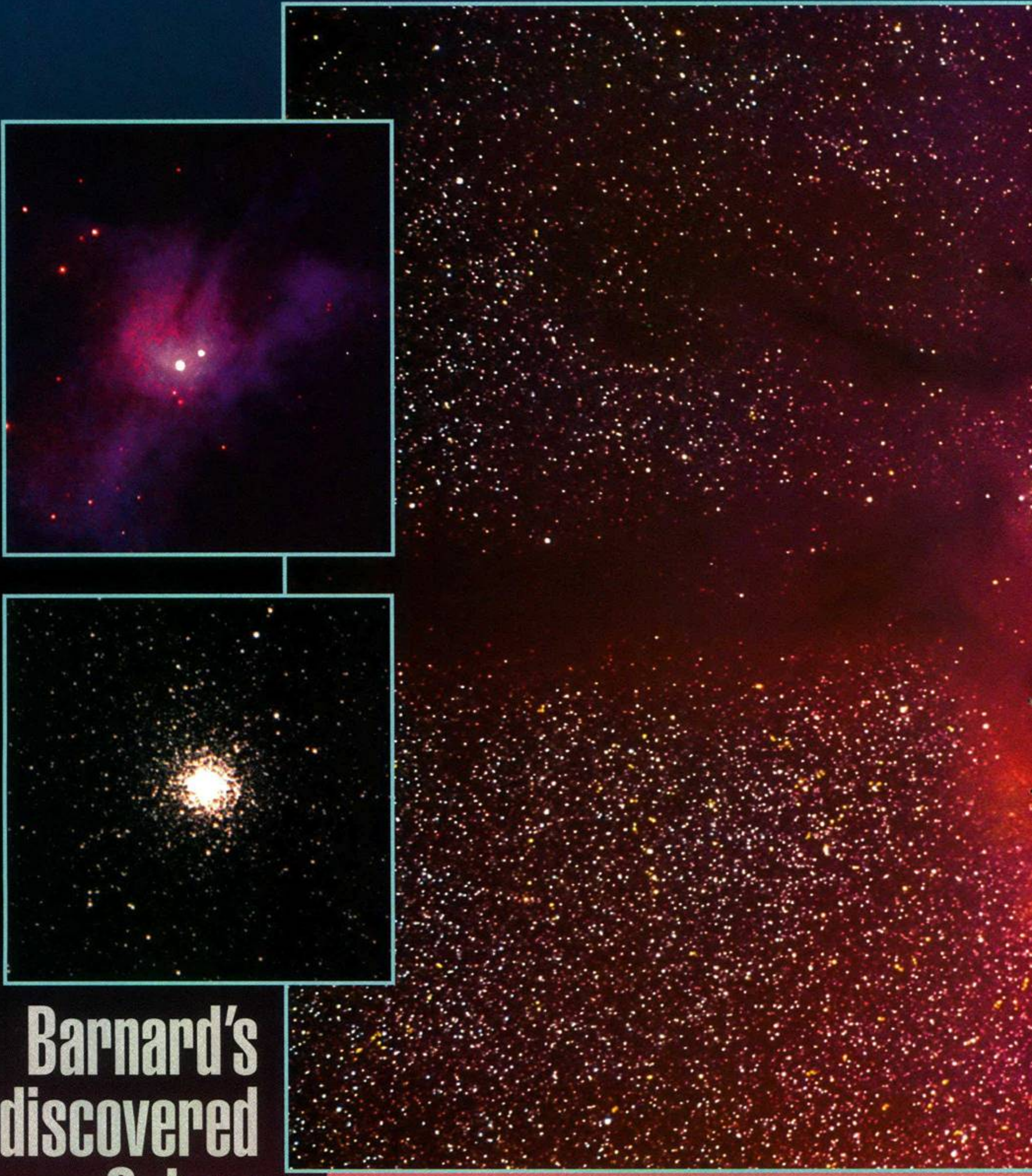
Also look for very elongated dark condensations aligned parallel to the belts. Known as rods or bars, these features are often isolated short sections of an otherwise invisible belt. You may also see dark protuberances lying along the edge of a belt. Called projections, these features are very common on the south edge of the NEB.

That's the same region where you will likely find ovals. These white, round or oval-shaped areas appear fairly large, bright, and well defined. Smaller and brighter spots, called nodules, are very common in the south polar regions. They usually appear round and not much bigger than the disk of Ganymede, Jupiter's largest moon. The final type of feature that occurs fairly frequently is a rift. Common in the NEB and SEB, this is a long, bright streak that extends horizontally along the interior of the belt.

You can usually see Jovian features more clearly when you use color filters. A good filter for enhancing the overall contrast between the belts and zones is a Wratten #82A (very light blue). To see the bluish festoons better, try a Wratten #25 (red) filter. Reddish clouds, on the other hand, show up nicely through a Wratten #38A (light blue) filter.

To precisely locate the position of a feature on Jupiter, record the time when it crosses the central meridian, the imaginary line that connects the planet's poles and passes through the center of the disk. You can then compute the longitude of the feature from published tables (see, for example, the Royal Astronomical Society of Canada's *Observer's Handbook*). Or if you own a computer that can run programs in BASIC, try the one that appeared in "Computing Mars and Jupiter," (July 1993.) If you're interested in more information about observing Jupiter, or in submitting reports of your observations, contact José Olivarez, ALPO Jupiter Recorder, 1469 Valleyview Court, Wichita, KS 67212.

Although beginners may view Jupiter as an unchanging planet with only a couple of dark belts, experienced observers know it as a world of features that never looks the same twice. With its ever-changing and colorful clouds, it is an endlessly fascinating world. Why not take time this summer to explore it on your own? □

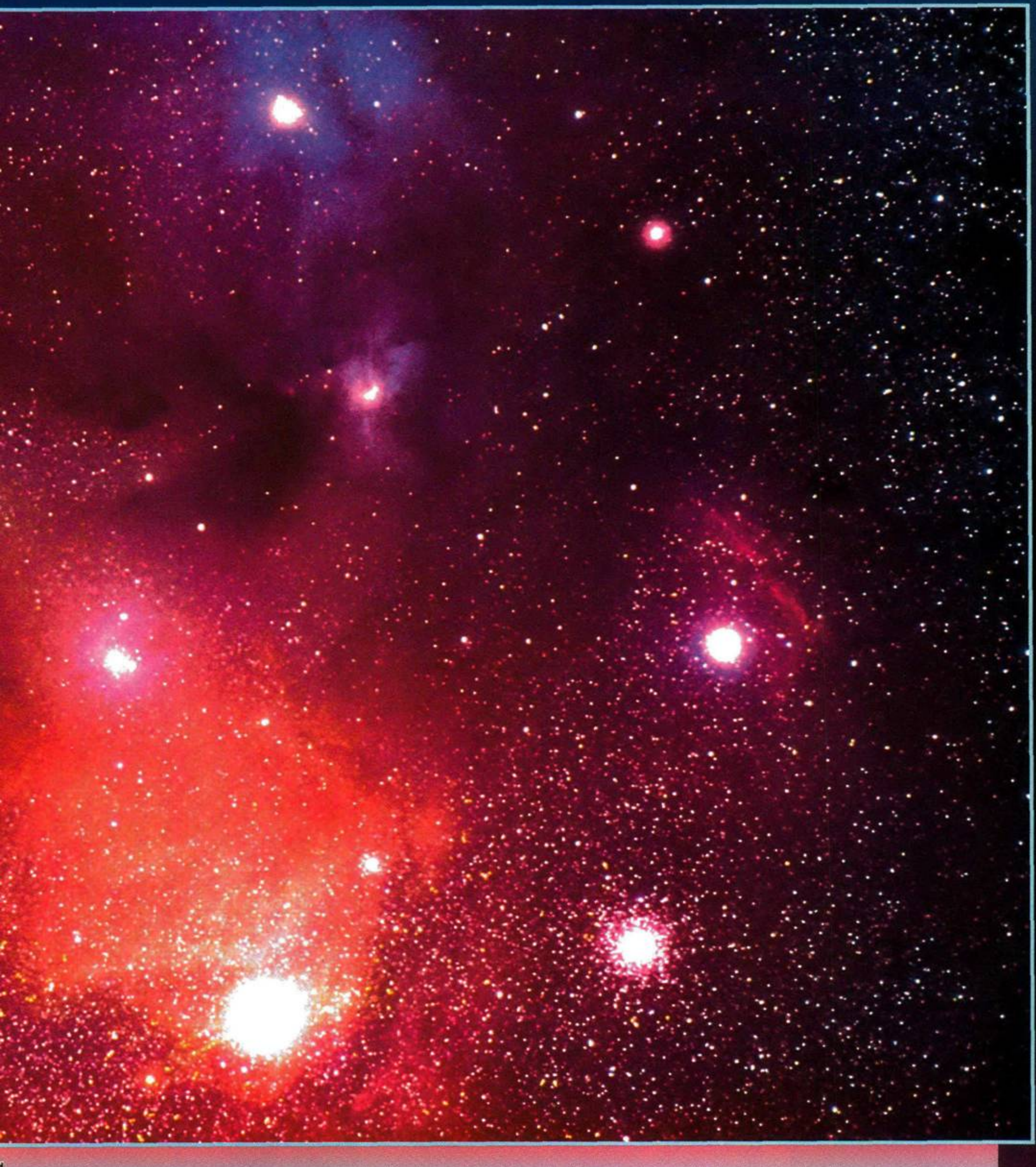


Barnard's Undiscovered Galaxy

We see a rich region of our Milky Way in ways that would have astounded the early astrophotographer.

by John Shibley

When E. E. Barnard first photographed this region of the Galaxy, he thought it was full of mysterious stellar voids and monochromatic clouds of glowing gas (see "Edward Barnard's Magnificent Milky Way," page 32). Now, almost 100 years later, modern astrophotography reveals a riot of color. Whole clouds of dust, the building blocks of future solar systems, waft along our gaze toward the Galaxy's center. For the most part this dust is dark as deep space itself, silhouetted against a stellar backdrop. In other spots, latent gas



glows red under the energetic ultraviolet radiation of embedded stars. Other tracts shimmer under the blue, icy reflection of starlight.

Barnard coined this area the Rho (ρ) Ophiuchi region, after a gas- and dust-cloaked 5th-magnitude double star that marks the complex's center (inset, top), slightly north of Antares. You'll need an 8-inch to glean the duo's faint, surrounding reflection nebula IC 4604. Just outside our line of sight with the Galaxy's center lies M4 (inset, bottom), one of perhaps 300 ancient globular star clusters that trace out lazy, 200 million-year orbits around the Milky Way's hub.

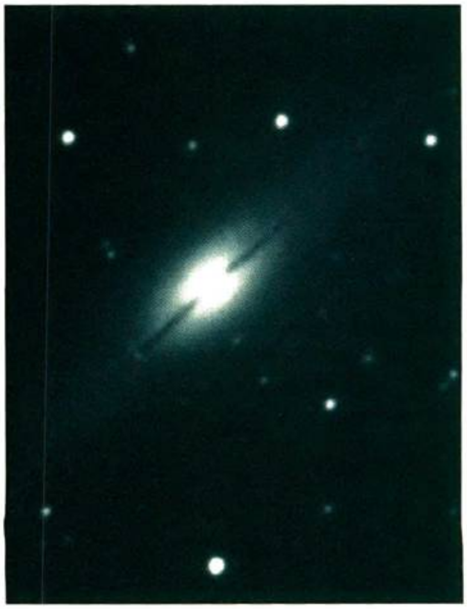
Barnard's ground-breaking photos uncovered this region's complexity. Today, even after years of intense study, we are still coming to terms with exactly what our cameras, and eyes, are telling us. ☐

A Night Owl's Guide to Galaxies

Tired of the bright Milky Way blocking your view of the universe beyond? Stay up late and nail the best galaxies of the autumn sky.

by David J. Eicher

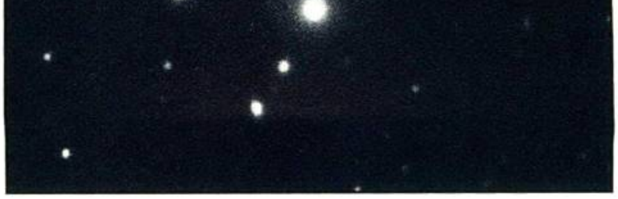
Come summer, you may need a break from the Milky Way. All that bright galactic stuff, open clusters and star factories, littering the backbone of the Galaxy and cluttering the sky? Forget it. They're way too bright for serious deep-sky observers. It's time to move on to the deep universe beyond, represented by a host of misty galaxies scattered across the evening sky of autumn. To see them means staying up into the wee hours of the morning. That's okay, though: Astronomers are born insomniacs.



Edge-on Spiral NGC 7814 in Pegasus

by Martin C. Germano (14.5-inch reflector at f/6, hypersensitized Tech Pan film, 90-minute exposure)

When you plan your all-nighter, gather some items beyond your scope, eyepieces, and star atlases. Memories of my high school days, when I used to routinely stay up all night observing, suggest several factors that help one push on through the night. First, bring a number of snacks and drinks that will keep your blood sugar level relatively high. Dissolving those carbs into the bloodstream helps maintain your alertness.



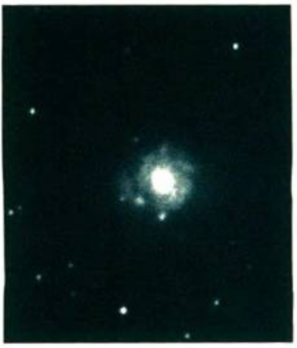
The NGC 70 Galaxy Group

by David Healy (14-inch SCT at f/7, hypersensitized Tech Pan film, 110-minute exposure)

Second, take a radio along. Music or all-night talk shows also help maintain a mental focus. Avoid taped reruns of Rush Limbaugh, though — you don't want observing to *subtract* intelligence. And stay relatively active. By that I mean check charts, adjust the knobs on the radio, and so on. You can be only so active standing or sitting about and looking through a scope, but if you get too relaxed the sleep hormones will win.

With that in mind, get ready to set off on an adventure through some familiar and some new and strange galaxies. By midnight Lyra and Hercules stand overhead and the Milky Way arches from Cassiopeia in the north to Sagittarius in the south.

We'll view a few warmup galaxies at this hour but hold in reserve most of our energy for the spirals, ellipticals, and irregulars that will rotate into a good position for viewing by about 2 a.m. Many of these objects will be clus-

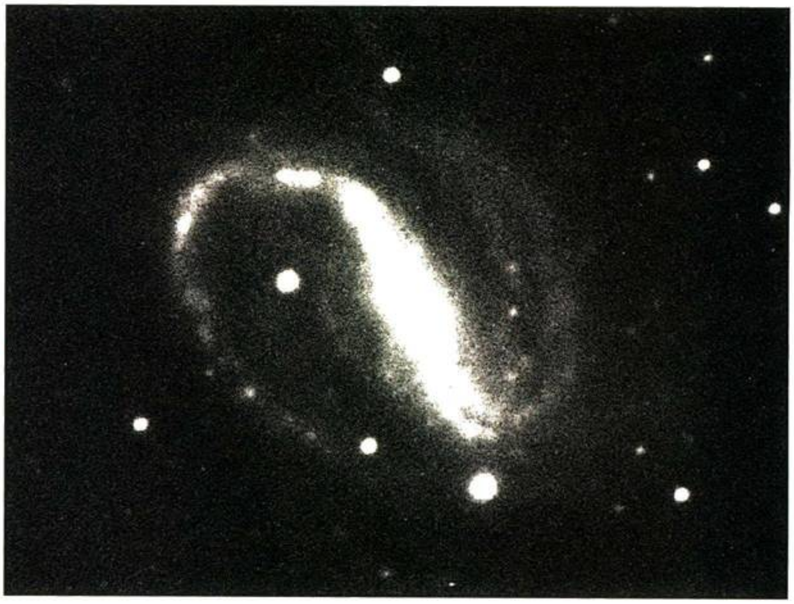


Elliptical Galaxy NGC 278 in Cassiopeia

by Kim Zussman (modified 11-inch f/10 SCT, hypersensitized Tech Pan film, 60-minute exposure)

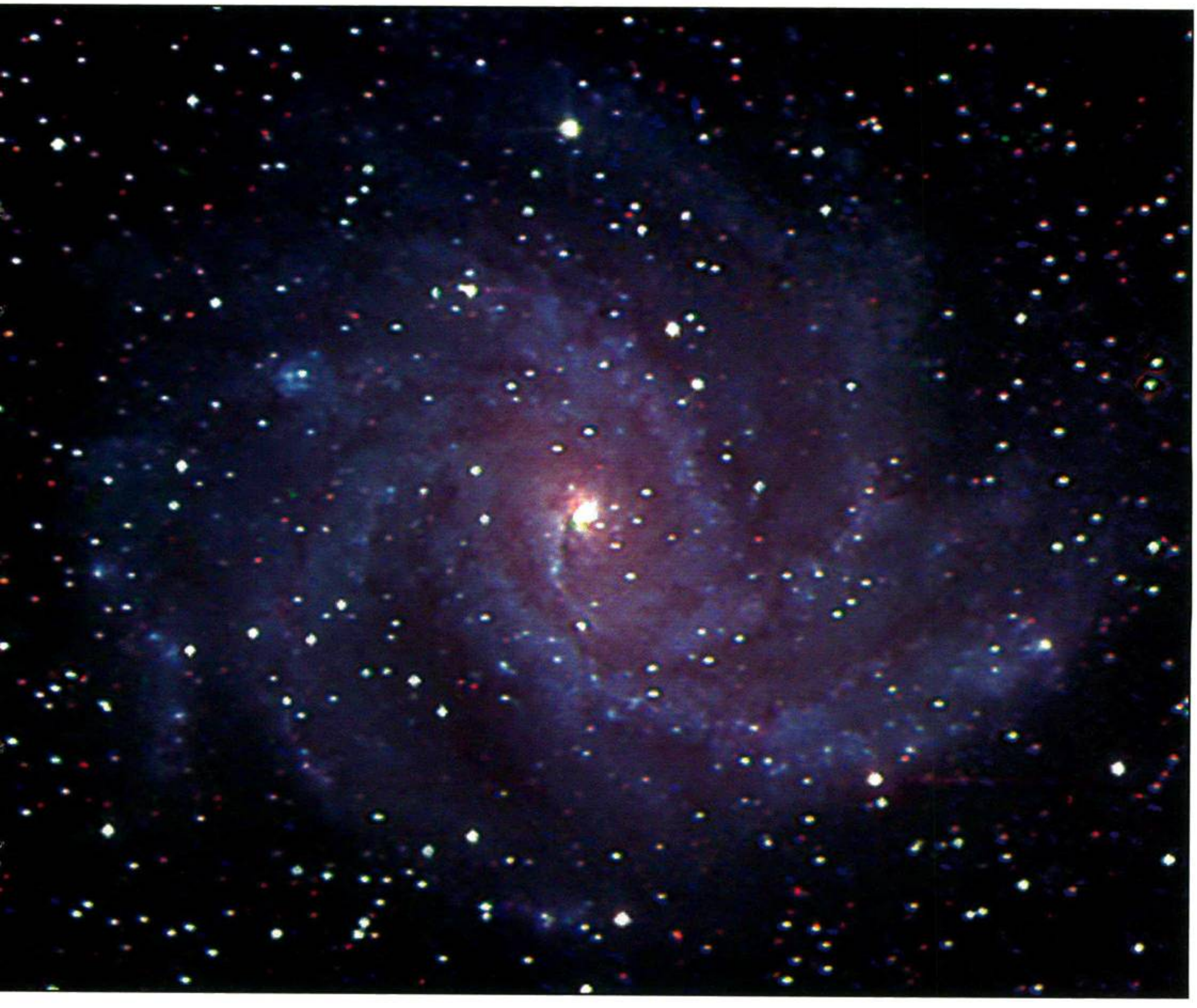
tered in Pegasus and a few in Aquarius. Still more come into view about 3 a.m. These include galaxies in Cetus, Sculptor, Andromeda, Pisces, Triangulum, and Cassiopeia. As star atlases go, try using *Sky Atlas 2000.0* by Wil Tirion (Cambridge, 1981) or *Uranometria 2000.0* by Wil Tirion, Barry Rappaport, and George Lovi (Willmann-Bell, 1987–1988).

It's the midnight hour. If you haven't already, take your scope, accessories, food, and radio outside and get situated. As your



Graceful Barred Spiral NGC 7479 in Pegasus

by Kim Zussman (modified 11-inch f/10 SCT, hypersensitized Tech Pan film, 150-minute exposure)

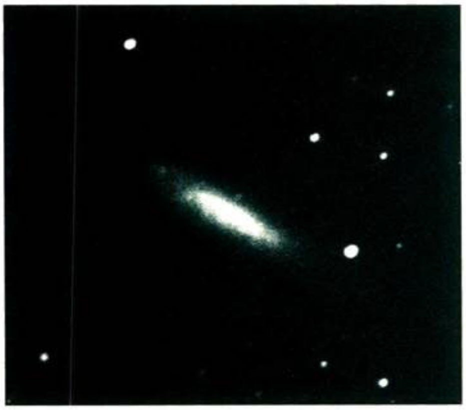


Face-on Spiral NGC 6946 in Cepheus

by Jack Newton (25-inch f/5 reflector, Pictor 1616 CCD camera)

Edge-on Spiral NGC 24 in Sculptor

by Harvey Freed (10-inch SCT at f/6, hypersensitized Tech Pan film, 62-minute exposure)



eyes adjust to the darkness, watch for meteors or — gasp! — look a little bit at that bright Milky Way stuff. But when you're ready to get serious, shift your focus onto Sagittarius.

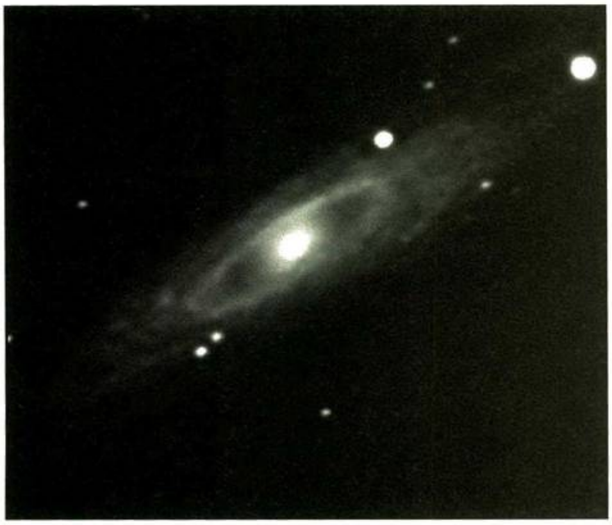
The northernmost arm of the constellation consists of a triangle of 5th-magnitude stars that includes 54 and 55 Sagittarii. A degree north of this triangle lies the elusive **Barnard's Galaxy** (NGC 6822), an irregular patch of gray-green light. (The galaxy was so named because the American astronomer Edward E. Barnard discovered it visually in 1884 using a 5-inch refractor.) This galaxy is a member of the Local Group, lying a mere 2 million light-years distant. However, its intrinsic dimness and the fact that it's partially obscured by our own galaxy's stars conspire to make Barnard's Galaxy a challenge in an 8-inch scope.

Long-exposure photos by backyard skyshooters resolve the galaxy's brightest stars into a cloud that approximates a load of white buckshot against black velvet.

Following the sky eastward and moving north brings you to a much brighter galaxy, **NGC 6946** in Cepheus. This face-on spiral lies in a field peppered with bright stars and measures 11' by 9.8', making it easily visible in small scopes. Look for it 2° southwest of the 4th-magnitude star Eta (η) Cephei.

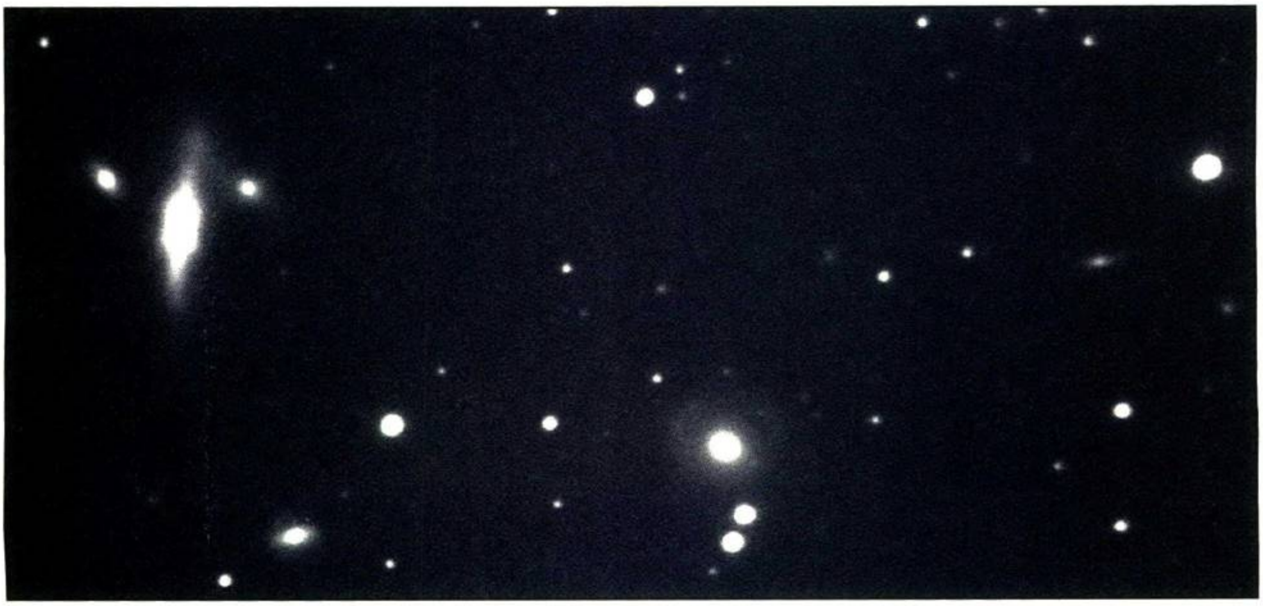
Following these few warm ups, wait until the tail of Pegasus climbs high enough to bask in a relatively dark sky. Continue eastward and drop south into Aquarius to find **NGC 7184**, a distant spiral with a curious ringlike structure. Find it nearly 3° west and just slightly north of the 6th-magnitude double star 41 Aquarii. Physically, this galaxy is a monster. It lies 120 million light-years distant and measures a respectable 5.8' by 1.8' in our sky.

A northward hop into Pegasus brings into view **NGC 7217**, a much easier target for small telescopes. You can find this



The Ringlike Disk of NGC 7184 in Aquarius

by Al Kelly (32-inch f/4 reflector, Cookbook 245 CCD camera, 255-second exposure)



The NGC 128 Galaxy Group

by James R. Foster (11-inch SCT at f/11, hypersensitized Tech Pan film, 210-minute exposure)

10th-magnitude, face-on spiral by aiming your finder scope at a spot 2° southwest of the bright double Pi (π) Pegasi. Spanning 3.7' by 3.2' and glowing with a high surface brightness, this galaxy is an easy pick for 4-inch scopes and reveals a bright, compact nucleus in 8-inch and larger instruments.

Just 6½° northeast of this galaxy, and 1° south of the bright spiral NGC 7331, lies one of the most renowned groups in the northern sky. **Stephan's Quintet** appears as a fuzzy glow in small scopes and a dance of individual galaxies in larger instruments. On a dark night, use moderately high power, focus sharply, and cruise slowly around the field, absorbing all the detail you can. The five galaxies are NGC 7317 (mag. 13.6, 1.0' by 0.8'), NGC 7318A (13.3, 1.0' by 1.0'), NGC 7318B (13.1, 1.9' by 1.3'), NGC 7320 (12.7, 2.2' by 1.2'), and NGC 7319 (13.1, 1.7' by 1.3'). As you observe this tight little group, appreciate the fix it presents for astronomers. The galaxies appear to be intertwined, and the radial velocities for four galaxies indicate distances of about 300 million light-years. The velocity for the brightest galaxy, however, suggests a distance of only 45 million light-years. Could the redshift method for determining distances be flawed? Unlikely, but Stephan's Quintet makes extragalactic astronomers a little uneasy, nonetheless.

Five more worthwhile insomniac galaxies inhabit Pegasus. As you push yourself to stay awake, slide your scope over to **NGC 7448**, found 1.5° northwest of Markab (Alpha [α] Pegasi), the star marking the southwestern corner of the Great Square. This 12th-magnitude spiral appears boxlike with a bright center in an 8-inch scope. It lies approximately 100 million light-years away.

The graceful barred spiral **NGC 7479** can be found 3° south of Markab. This lovely object shows a bright center and very faint spiral arms. It sits about

Barnard's Galaxy in Sagittarius

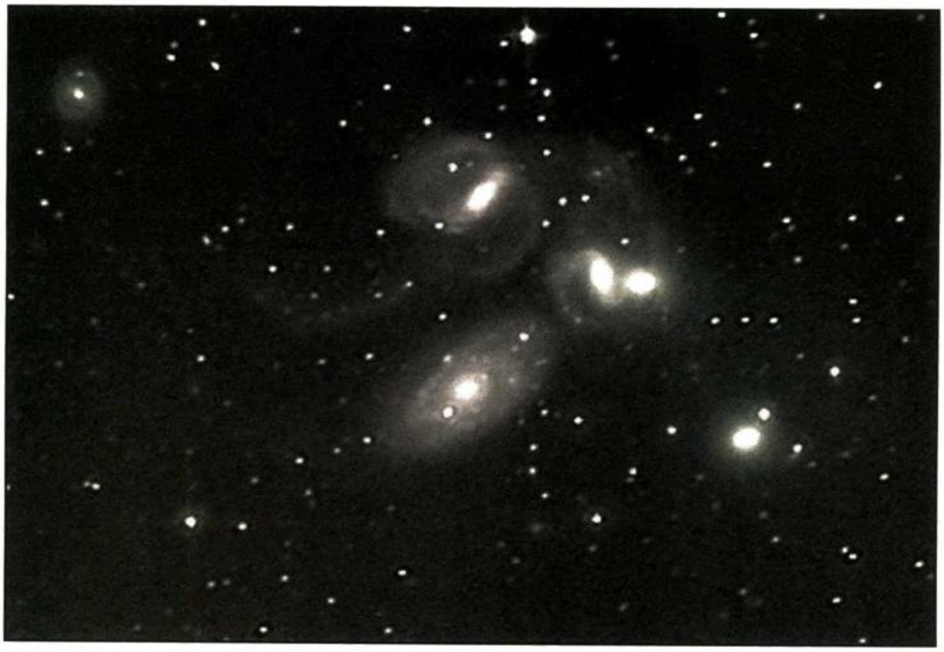
by Martin C. Germano (14.5-inch f/5 reflector, hypersensitized Tech Pan film, 75-minute exposure)

NGC 45's Knotty Spiral Arms

by Martin C. Germano (14.5-inch f/5 reflector, hypersensitized Tech Pan film, 90-minute exposure)

Stephan's Quintet in Pegasus

by Jack Newton (25-inch f/5 reflector, Pictor 1616 CCD camera)

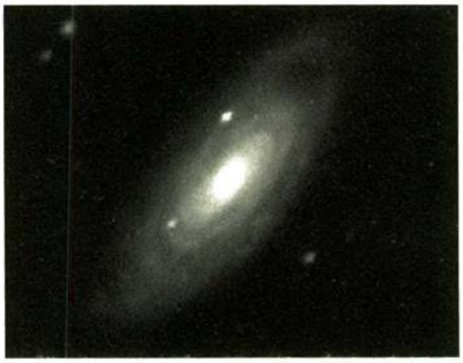


NGC 7217's Faint Outer Halo

by Kim Zussman (14.5-inch f/8 Cassegrain, hypersensitized Tech Pan film, 120-minute exposure)

The Tightly-Wound Arms of NGC 7606

by Allen Gilchrist and Matt Delevoryas (14-inch SCT at f/7, Cookbook 245 CCD camera, 8-minute exposure)



110 million light-years away. The faint and challenging barred spiral **NGC 7497** sits some 3° north-northeast of Markab, and appears like a streak of light shaped like a cigar. Don't expect to see much detail in this 13th-magnitude object. Move up to Scheat (Beta [β] Pegasi), then 2° north and a little west, to find **NGC 7457**. This 11th-magnitude elliptical galaxy sits only 35 million light-years away, making it closer than the benchmark Virgo Cluster. The edge-on spiral **NGC 7814**, a short, fat object with a razor-thin dust lane bisecting it, is an easy target in 4-inch or larger scopes. Seeing the edge-on shape clearly, however, may require a somewhat larger scope. Look for this galaxy 3° northwest of Algenib (Gamma [γ] Pegasi), the star at the southeastern corner of the Great Square.

Peculiar Galaxy NGC 7457 in Pegasus

by Joe Peck (2-inch f/10 SCT, ST-6 CCD camera, composite of ten 30-second exposures)

Now it's early morning. The weight of your eyelids may be a heavy consideration. Listening to the deep-sky fanatic in you, however, will drag your senses over to some treasures in Aquarius. Try spotting **NGC 7606**, a distant spiral with a bright, oval hub and very faint outer spiral arms that will challenge observers armed with 12-inch scopes. This galaxy is extremely easy to find, lying 1° north of the center of the three bright stars Psi^1 (ψ^1), Psi^2 (ψ^2), and Psi^3 (ψ^3) Aquarii. Similar in size and brightness is Sculptor's **NGC 24**, a spiral located 26 million light-years away. This fine object

Galaxies for Summer Insomniacs

Galaxy	R.A.(2000)Dec.		Magnitude	Size	Type	Con.	Distance
NGC 7814	0h03.3m	16°09'	10.5	6.3' by 2.6'	Sb$^-$	Peg	55 M ly
NGC 24	0h09.9m	–24°58'	11.5	5.5' by 1.6'	Sb	Scl	26 M ly
NGC 45	0h14.1m	–23°11'	10.4	8.1' by 5.8'	S$^-$	Cet	22 M ly
NGC 70	0h18.4m	30°05'	14.5_P	1.7' by 1.5'	Sc	And	320 M ly
NGC 128	0h29.3m	2°52'	11.6	3.4' by 1.0'	S0 pec	Psc	190 M ly
NGC 210	0h40.6m	–13°52'	10.9	5.4' by 3.7'	Sb$^-$	Cet	75 M ly
NGC 278	0h52.1m	47°33'	10.9	2.2' by 2.1'	E0 pec	Cas	38 M ly
M33	1h33.9m	30°39'	5.7	62' by 39'	Sc	Tri	3.5 M ly
NGC 925	2h27.3m	33°35'	10.0	9.8' by 6.0'	S(B)c	Tri	30 M ly
Barnard's Galaxy (NGC 6822)	19h44.0m	–14°48'	9.4_B	10.2' by 9.5'	Ir$^+$	Sgr	2 M ly
NGC 6946	20h34.8m	60°09'	8.9	11.0' by 9.8'	Sc	Cep	15 M ly
NGC 7184	22h02.7m	–20°49'	12.0_B	5.8' by 1.8'	Sb$^+$	Aqr	120 M ly
NGC 7217	22h07.9m	31°22'	10.2	3.7' by 3.2'	Sb$^-$	Peg	50 M ly
Stephan's Quintet							
NGC 7317	22h35.9m	33°57'	13.6	1.0' by 0.8'	E2	Peg	300 M ly
NGC 7318A	22h35.9m	33°58'	13.3	1.0' by 1.0'	E2 pec	Peg	300 M ly
NGC 7318B	22h36.0m	33°58'	13.1	1.9' by 1.3'	SBb$^+$ pec	Peg	300 M ly
NGC 7320	22h36.1m	33°57'	12.7	2.2' by 1.2'	Sd	Peg	45 M ly
NGC 7319	22h36.1m	33°59'	13.1	1.7' by 1.3'	SBb$^+$ pec	Peg	300 M ly
NGC 7448	23h00.1m	15°59'	11.7	2.7' by 1.3'	Sc	Peg	100 M ly
NGC 7457	23h01.0m	30°09'	10.8	4.4' by 2.5'	E pec	Peg	35 M ly
NGC 7479	23h04.9m	12°19'	11.0	4.1' by 3.2'	SBb$^+$	Peg	110 M ly
NGC 7497	23h09.1m	18°11'	12.8_B	5.0' by 1.5'	SBc	Peg	85 M ly
NGC 7606	23h19.1m	–8°29'	10.8	5.8' by 2.6'	Sb$^+$	Aqr	100 M ly
NGC 7640	23h22.1m	40°51'	10.9	10.7' by 2.5'	S(B)b$^+$	And	28 M ly

This table provides **right ascension** and **declination** in epoch 2000.0 coordinates; **V magnitude** (except a subscript B, which denotes a B magnitude; or a subscript P, which denotes a photographic magnitude); **size** in arcminutes; the revised **Hubble classification** of galaxy types; the **constellation** that contains the galaxy, and the galaxy's **distance** in millions of light-years, based on a Hubble constant of 75 km/sec/Mpc.

Barred Spiral NGC 925 in Triangulum

by Martin C. Germano (14.5-inch f/5 reflector, hypersensitized Tech Pan film, 90-minute exposure)

appears as an elongated smear of light in small scopes. Just 2° north-northeast, try picking up **NGC 45**, a spiral with loose, knotty arms located in Cetus. Also in Cetus, spot **NGC 210**, a galaxy with an oval center and extremely faint, delicate spiral arms.

As long as you're pulling the graveyard shift, several more galaxies lie scattered across Andromeda, Pisces, and Cassiopeia. **NGC 70**, the brightest galaxy in a remote group found in Andromeda, will challenge even large scope users. The NGC 70 galaxy group lies at a distance of 320 million light-years, so NGC 70 itself is a 14th-magnitude glow measuring 1.7' by 1.5'. Look for it on very dark nights 2° northeast of Alpheratz (Alpha Andromedae). **NGC 128**, in Pisces, lies in a barren region 7° southwest of Delta (δ) Piscium. It, too, is surrounded by a group lying 190 million light-years away. Cassiopeia's treat is **NGC 278**, a bright elliptical.

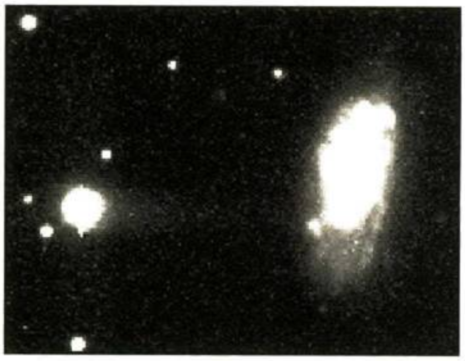
Consider ending your visual tour with the demure constellation Triangulum. **M33** (NGC 598), sometimes called the Pinwheel Galaxy, is the second brightest spiral in the sky, a fellow member of the Local Group of galaxies lying a mere 3.5 million light-years away. Visible on the darkest of nights to the naked eye, a fuzzy glow in binoculars, a rich playground for very large telescopes, it somehow fails to impress the small telescope user. Spend some time with M33, even if your eyes are blurry, and appreciate the intricacies of its nature. Then move to **NGC 925**, a barred spiral that would be a legend if it didn't rest in the shadow of M33.

And now go get some sleep — what, do you want to destroy your health? □

Dave Eicher (deicher@astronomy.com) is associate editor of this magazine. In addition to his astronomical pursuits, he has written two books about Civil War history.

Spiral Galaxy NGC 7448 in Pegasus

by Dale Mais (14-inch SCT at f/7, ST-7 CCD camera, 20-minute exposure)

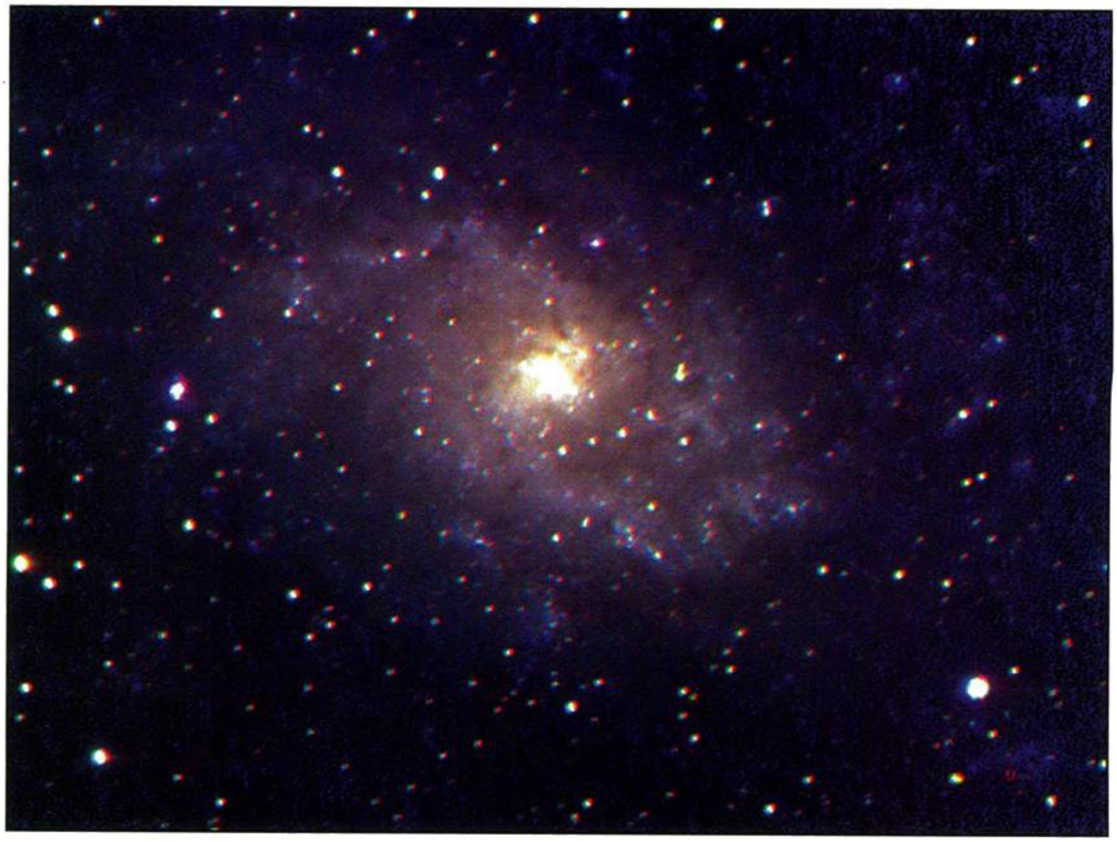


NGC 210's Delicate Spiral Arms

by Bruce D. Macdonald

Spiral M33 in Triangulum

by Jack Newton (25-inch f/5 reflector, Pictor 1616 CCD camera)



Edge-on Barred Spiral NGC 7640 in Andromeda

by Martin C. Germano (14.5-inch f/5 reflector, hypersensitized Tech Pan film, 85-minute exposure)

Hooray for Comet Hyakutake!

At long last, a bright comet appears to delight astronomers and the general public.

by David J. Eicher

It's Friday, March 22, and I'm sitting on the deck looking skyward, after scarfing a quick dinner. The comet is brilliant now, mocking the purpose of hastily-constructed maps from the office. Comet Hyakutake (1996 B_2) gleams softly overhead, its big, blobby coma three times the size of the Moon. Its greenish-white tail stretches from near Arcturus over at least 10° of sky. My three-year-old son walks outside and spots the comet, fascinated as much by the new word *comet* as by the fact that he is looking at a chunk of dirty ice whizzing past Earth a mere 9 million miles away.

For thousands of backyard astronomers and the public at large, it seemed like a dream, or a flashback to the glory days of Comet West in 1976. But the new bright comet, discovered by Japanese amateur Yuji Hyakutake (yah-koo-tah-kee) on January 30, 1996, who used 25x150 binoculars, was no dream. On calculating the comet's orbit, astronomers found it would put a great show.

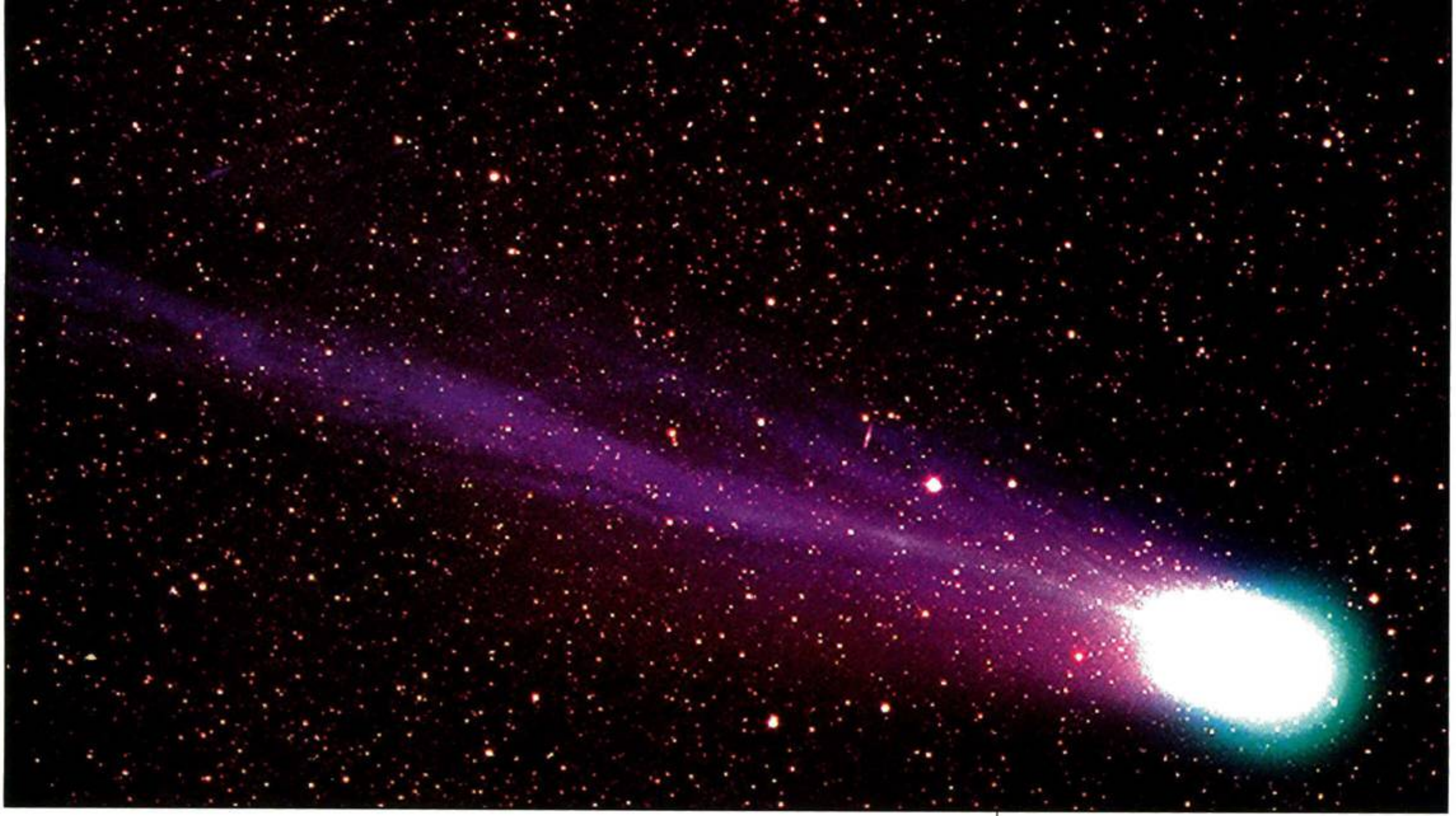
In March Hyakutake swung past Arcturus on its speedy northward route and landed as a circumpolar object. Its brightness and tail length exceeded even the most optimistic predictions: by March 19 it shone at 2nd

Cometrise over Joshua Tree

by Bob Yen (85mm lens at f/1.8, Fuji Super G800 film, 8-minute exposure taken March 20, 1996; flash used at end of exposure to light the Joshua Tree)

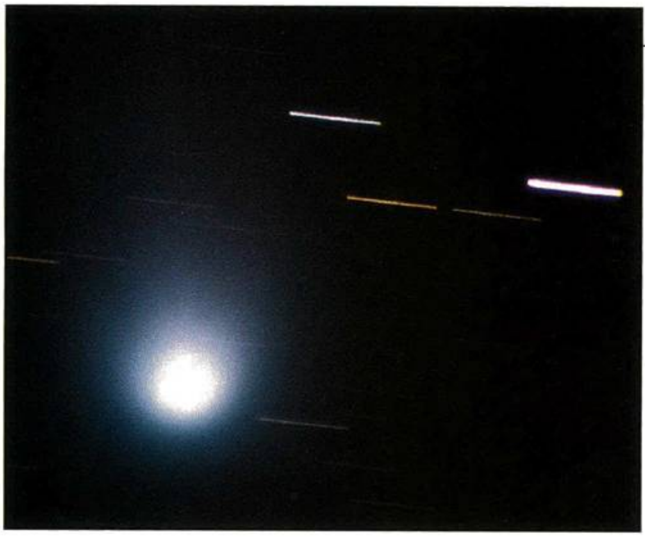
Hyakutake's Beautifully Colored Tail

by Jack Newton (300mm lens at f/2.8, Pictor 1616 CCD camera, 60-second exposure taken March 18, 1996)



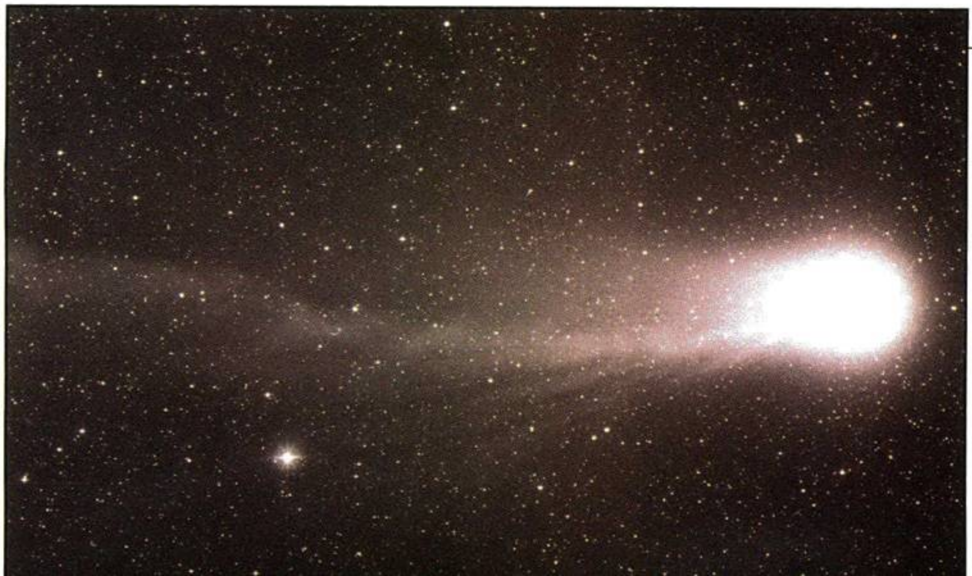
Comet Hyakutake Brightens to Naked-Eye Splendor

by Bob Yen
(8-inch f/1.5 Schmidt camera, Fuji Super G800 Plus film, 4-minute exposure
taken March 20, 1996)



Hyakutake's Bright Inner Coma

by John Chumack
(6-inch f/10 refractor,
Royal Gold 100 film,
60-minute exposure
taken March 16, 1996)



The Comet Develops a Broad Tail

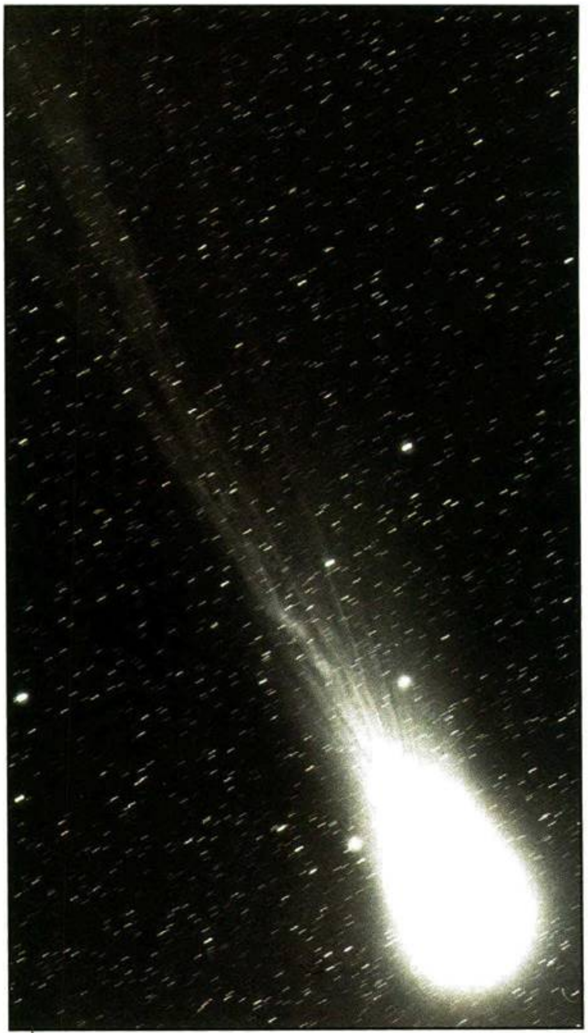
by Chris Schur
(5.5-inch f/1.65 Schmidt camera, hypersensitized Tech Pan film, 6-minute exposure taken March 18, 1996)

magnitude and displayed a 5°-long tail, the coma appearing fan-shaped with a jet or two visible near the nucleus.

By March 25, its closest approach to Earth, the comet had erupted in brightness, shining at magnitude –0.5, and its tail stretched some 50° across the sky, from near Polaris all the way to Coma Berenices. Under a very dark sky, observers reported tail lengths of 100°. It was a shocking sight to those who had never before seen a bright comet. And the national news media, roused from their slumbers of dull comets from recent years, awoke with an explosive round of coverage, much of it garbling the facts of what the comet is and how to best see it.

Despite this, amateurs around the globe took notice. Mike Beauchamp of Marquette, Michigan, describes his view on March 7 with a 10-inch reflector: "It appeared as a dimly glowing patch of light with a bright center, reminding me of a small globular cluster." But two weeks later, on March 20, atop Mauna Kea, Hawaii, John Dvorak used 10x50 binoculars and described the comet as "about 6° across, with fine structure and streaks readily seen along the tail. Wow!"

A night later, I observed the comet from a relatively good suburban site. I watched the comet for several hours with the naked eye, 7x35 binoculars, a 4¼-inch reflector, and an 8-inch SCT. The small reflector at 16x provided by far the most satisfying view, with the fan-shaped coma easily visible and a tail that stretched beyond an entire field. At low power in the 8-inch, however, the brilliant, condensed shining ball of the inner coma, surrounded by the huge, gauzy outer coma, struck me as amazing.



The Comet's Blazing Coma and Growing Tails

by Gerald Rhemann and Franz Kersche (7-inch Schmidt camera, hypersensitized Tech Pan film, 12-minute exposure taken March 19, 1996)

Closeup on the Comet's Nucleus

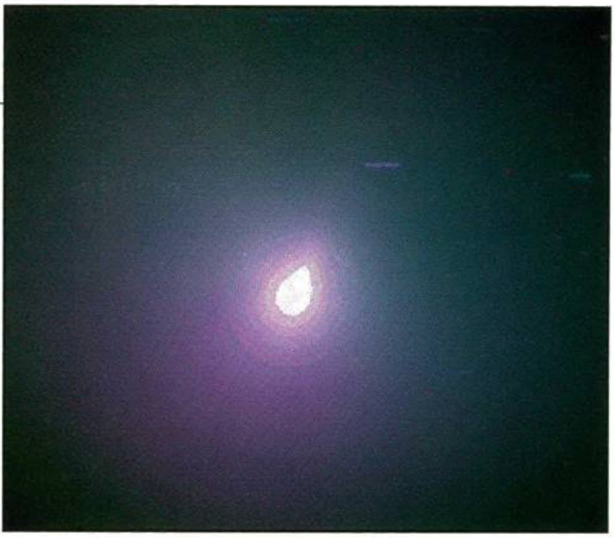
by Jack Newton (25-inch f/5 reflector, Pictor 1616 CCD camera, 30-second exposure taken March 18, 1996)

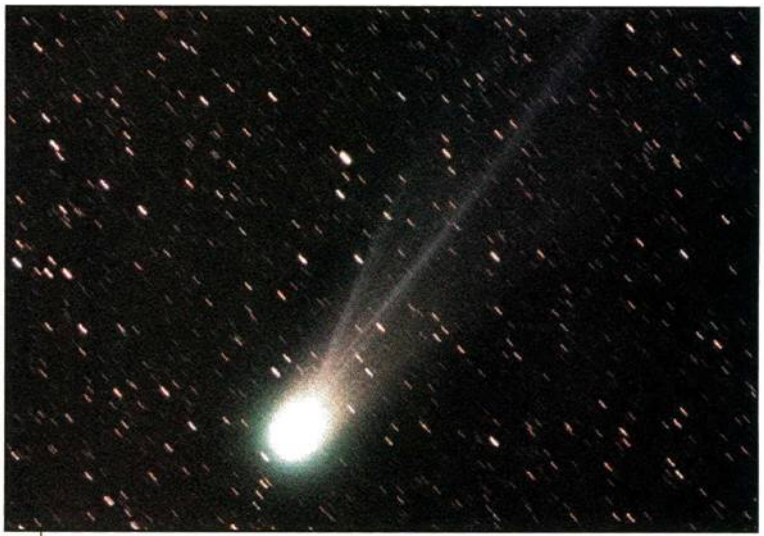
Rays in Hyakutake's Ion Tail

by Walt Harris/NOAO (3.5-meter WIYN telescope on Kitt Peak, Arizona, taken March 11, 1996)

The Innermost Coma and Nucleus

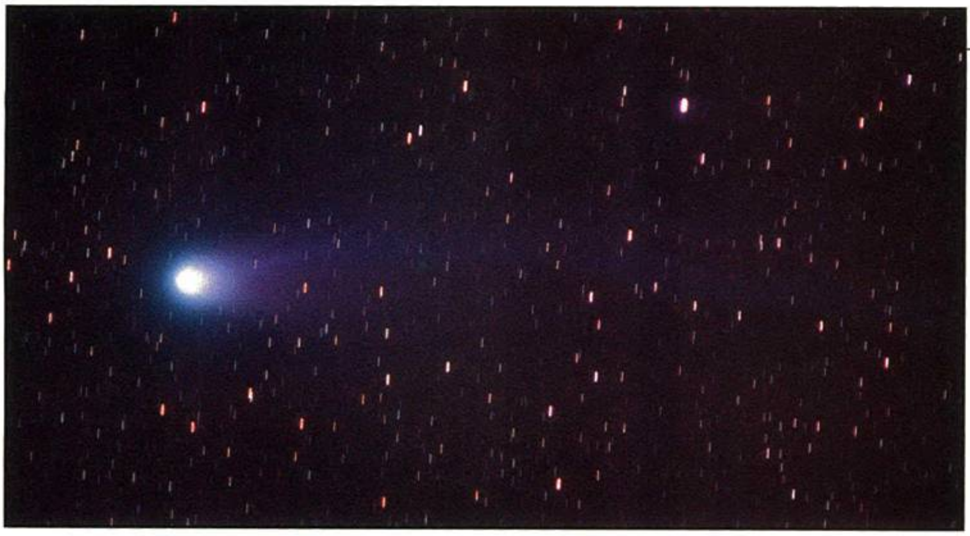
by Yanga R. Fernandez/NOAO
(0.9-meter telescope at Kitt Peak,
Arizona, taken March 21, 1996)





Hyakutake's Sharply Defined Tail

by Juan J. Escude
(135mm lens at f/2.8, Fuji 1600 film,
14-minute exposure taken March 21, 1996)



The Comet's Tail Appears Curved

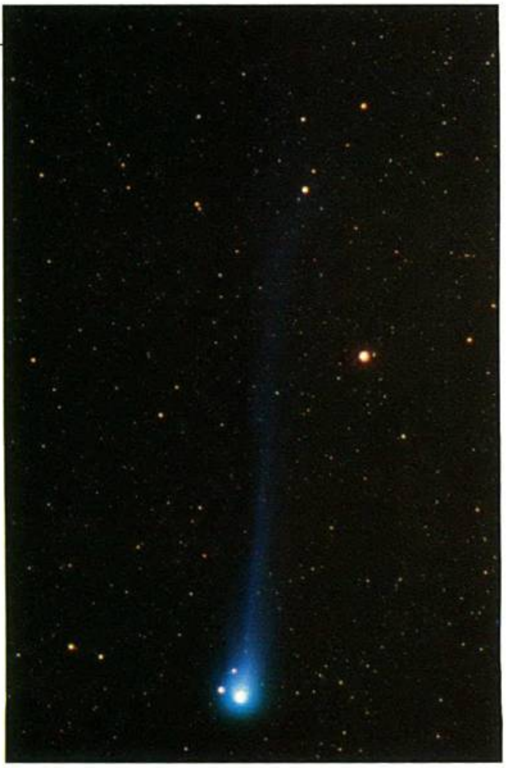
by David Healy
(300mm lens at f/4,
ScotchChrome 400 film,
20-minute exposure
taken March 17/18, 1996)

On the same night, Brian Skiff observed the comet from a dark sky location at Anderson Mesa, Arizona. "The comet is simply stunning," he wrote. "The tail goes right to the zodiacal band where it merges with the gegenschein, passing between Gamma and Delta Virginis — check those charts, boys and girls, that's 30°!" Skiff went on to record a spur from the main tail visible in 7x35 and 10x50 binoculars and estimated the comet's brightness as magnitude 1.7. The core of the coma appeared "not quite stellar," said Skiff, who made the point that at closest approach the image scale of the comet would be 75 km/arcsecond, enough to see country-sized features on the comet's image. On the 21st the comet moved along at 17.5' per hour, so that motion was visible in a few minutes when using binoculars.

But this was just a start. At its brightest on March 25, the comet surprised everyone. Atop Mauna Kea, Dvorak recorded that the tail stretched "from the head of the comet near the Little Dipper to Coma Berenices — that's 50°. What a sight!" Normand Matte of Montreal wrote that he "just had to tell someone the pleasure I had of seeing my first comet." He didn't believe it would be so easy to observe with his own eyes until seeing it for himself.

The first blush for Comet Hyakutake was over: The comet had redeemed the tarnished reputation of recent poor showings by other, hyped comets. Next month's issue will continue our coverage. ☐

Dave Eicher is an associate editor of this magazine. He has looked at all the good comets since West under the chilly skies of early spring 1976.

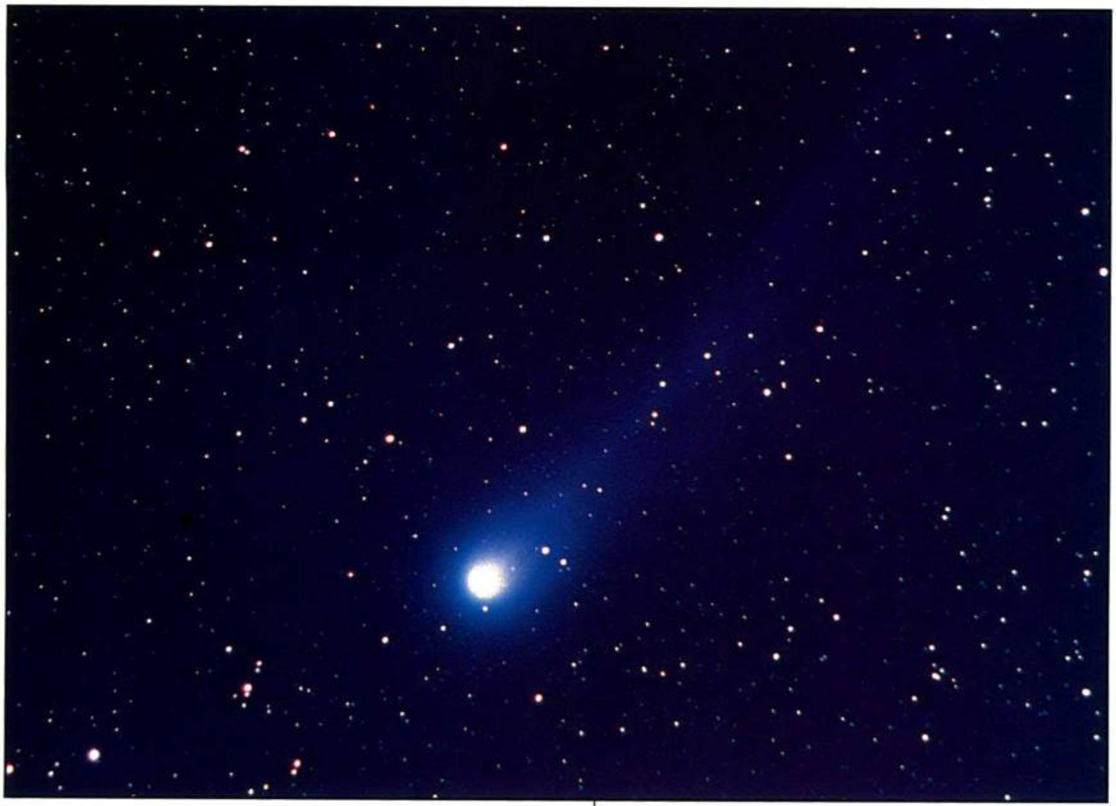


Hyakutake's Tail Reaches 15° Long

by John Shibley (50mm lens at f/4, Kodak Royal Gold 1000 film, 10-minute exposure taken March 23, 1996)

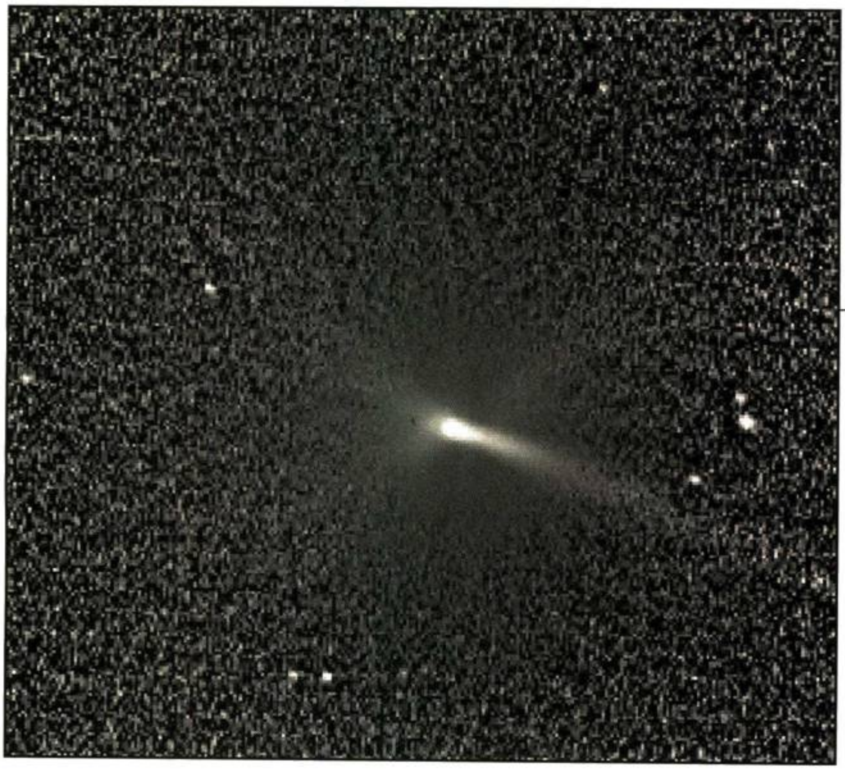
Striations in Hyakutake's Tail

by David Hanon
(300mm lens at f/2.8, ST-8 CCD camera,
5-minute exposure taken March 22, 1996)



The Pretty Colors of a Bright Comet

by Alberto Levy
(8-inch f/1.5 Schmidt
camera, Fuji 100 Sensia
film, 15-minute exposure
taken March 17, 1996)



Jets in the Comet's Inner Coma

by Tim Puckett
(12-inch reflector at f/7,
ST-6 CCD camera,
taken March 21, 1996)

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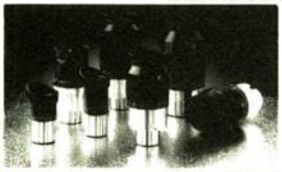

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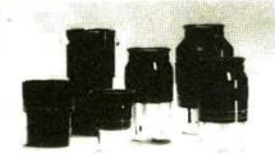

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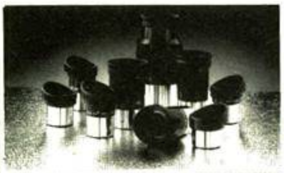

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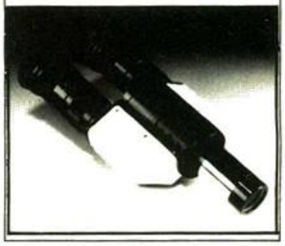

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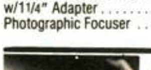

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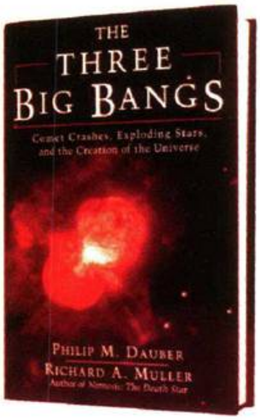
WRITE NO. 8 ON THE READER SERVICE CARD

Constructive Catastrophes

by William Sheehan

The Three Big Bangs: Comet Crashes, Exploding Stars, and the Creation of the Universe
Philip M. Dauber and Richard A. Muller, (Addison-Wesley, 1996), ISBN 0-201-40752-3, 207 pages, $25.00.



The prevailing image of the universe in the 18th and 19th centuries was the majestic clockwork – a stable, self-regulating, and timeless system, in which the planets glided mechanically around the Sun in accordance with Newton's law of gravitation. This static view of the heavens was paralleled by a gradualist, uniformitarian view of the Earth in which incremental forces continually raised and leveled mountains.

In the last few decades, the metaphor of the cosmic shooting gallery has replaced that of the majestic clockwork. Gradualism alone does not suffice to account for the solar system's birth, the Earth, or the variety of Earth's life-forms. Relatively uniform periods of evolution have been punctuated with catastrophic events on a grand scale, wreaking almost inconceivable violence.

Statistically, such events are rare. Astronomers estimate that the chance of Earth being struck by a 5-kilometer-wide asteroid, which is sufficient to produce mass extinctions, is only once per 100 million years. Nevertheless, over the long haul catastrophic impacts can and do occur. The heavily battered surfaces of the Moon, planets, and satellites testify to this, as do numerous impact basins scattered over the surface of the Earth. The now-famous 170-kilometer-wide Chicxulub crater buried in the Yucatán peninsula of Mexico testifies to the devastating impact that wiped out two-thirds of plant and animal species on Earth, including the dinosaurs. Their disappearance gave the early mammals – our own ancestors – their chance to take center stage in the drama of life.

This discussion will be at least somewhat familiar to many readers of ASTRONOMY; but writer Philip M. Dauber and Cal-Berkeley physicist Richard A. Muller have managed to produce a stimulating series of essays about these and other cosmic catastrophes. Their writing about intricate astrophysical processes is impressively clear and lucid. As always there are a few nits to pick. For instance, I was surprised to see a reference to "Harvard University's Lowell Observatory," a misconception that Percival Lowell thought he had cleared up in 1894, but few factual errors related to the main topics.

One of the most interesting essays deals with Muller's theory (first detailed in his earlier book, *Nemesis: The Death Star*) that a small companion star to the Sun periodically triggers mass extinctions by dislodging comets from the Oort comet cloud. The authors admit this idea is speculative, and it will remain so until astronomers can identify the star responsible (if it exists). After describing the catastrophes occurring within the confines of the solar system, the authors discuss even more mind-boggling events: supernovae, which occur when whole stars self-destruct and scatter their debris through space (thereby sowing the heavier elements from which rocky planets like Earth, and life, were formed). Their discussion of the Crab Nebula, its origins, and the pulsar at its heart is particularly interesting. Finally, they consider the big bang, which triggered the universe itself.

Though individually these events may seem haphazard or accidental, the authors link them together skillfully in a way that suggests a satisfying interconnectedness of things. Dauber and Muller have succeeded in capturing the excitement of their field through what is perhaps the reigning metaphor of our time – violence and cataclysm. We are the heirs, the progeny, of a series of cataclysms, occurring in far-away places and times. After reading *The Three Big Bangs*, one will never again see the quiet solitude of the starry night sky in quite the same way.

William Sheehan, a psychiatrist and amateur astronomer from Hutchinson, Minnesota, also wrote the article on E. E. Barnard in this issue.

More New Books

Other Worlds: A Beginner's Guide to Planets and Moons
Terence Dickinson, (Firefly Books, 1995), ISBN 1-895565-70-7, 64 pages, softcover, $9.95.

Aimed at children in the 4th grade and up, *Other Worlds* begins its tour of the solar system with an overview of the universe and our place in it. Dickinson, a well known Canadian science writer, next describes how our planetary system formed before visiting the first stop on the journey, the Moon. After describing the planets of the inner solar system, Dickinson launches us toward Jupiter and its satellites, Saturn and its rings, Uranus, Neptune, and Pluto.

Outer Worlds next takes us out to the Kuiper belt where many comets originate. Dickinson also tells the story of Comet Shoemaker-Levy 9's crash into Jupiter in July 1994.

Do other planets exist in our galaxy? Dickinson investigates the possibility that they do and describes novel worlds that circle burned out stars called pulsars.

Colorful photographs, illustrations, and paintings appear on every page. The paintings, provided by David Egge and John Bianchi, should fuel youngsters' imagination. The book includes beautiful photos, some taken by NASA spacecraft, and some by the author himself. □

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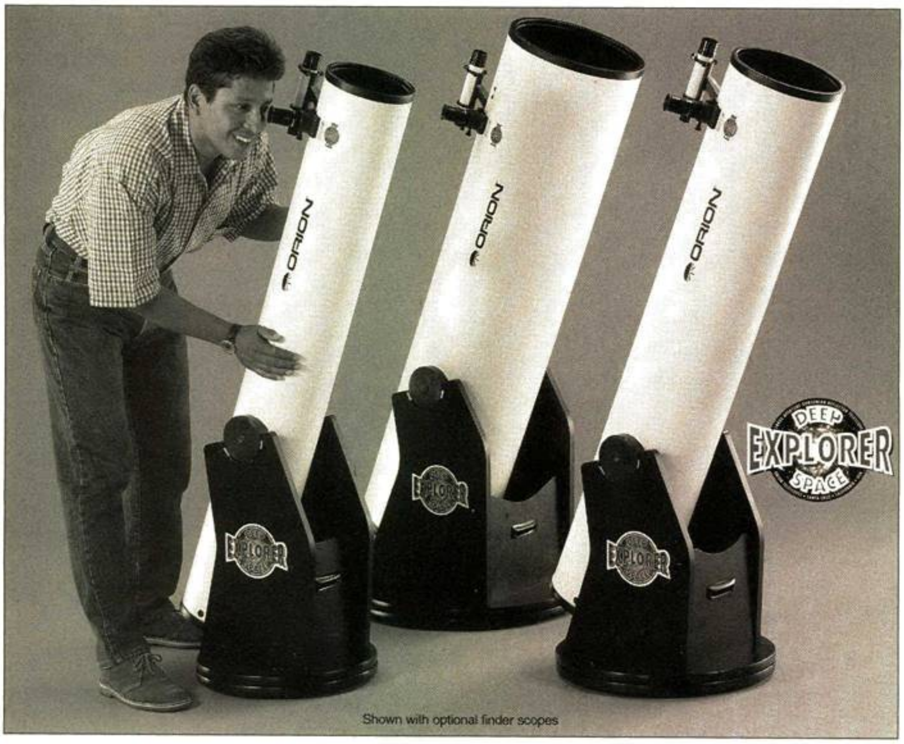

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- Oversized knob-style motion locks and cable controls.
- Strong adjustable aluminum tripod with eyepiece tray.
- Achromatic 6x30 finder scope with two-ring bracket.

SkyView™ 90mm Refractor

This fantastic large-aperture refractor telescope features a multi-coated f/11 achromatic objective lens for superb images. Especially suited to planetary, lunar, and stellar observation, its aperture is large enough to give spectacular views of star clusters and nebulas. Smooth rack-and-pinion 1.25" focuser, 90° prism diagonal, and **two** Kellner eyepieces, 25mm (40x) and 9mm (111x).

#9072 **$599** (28.30)

SkyView™ 4.5" Reflector

This all-new reflector is ideal for the beginning astronomer who wants the features of an equatorial mount, without compromising stability. The 114mm-diameter (4.5") precision optics are great for deep-space and planetary observation. Includes smooth rack-and-pinion 1.25" focuser and **two** Kellner eyepieces, 25mm (36x) and 9mm (100x). f/8 focal ratio.

#9071 **$399** (26.58)

Observer 60mm Refractor

Great for viewing Saturn's rings, lunar craters, and distant earthly scenes. Features an all-metal optical tube and altazimuth mount, precision prism-type diagonal and coated 25mm (28x) Kellner eyepiece, and hardwood tripod. Compare with models selling for much more! Standard model has 90° diagonal prism for stargazing; Terrestrial model includes 45° correct-image diagonal better suited for ground observation.

Standard Model
#9079 **$149** (7.27)

Terrestrial Model
#9088 **$199** (7.27)

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Eyepieces and Barlows

Orion 5-Element Ultrascopic™ Eyepieces

With Superb, High-Performance Ultra™ Multi-Coatings!

Ultrascopic eyepieces yield the highest contrast, greatest light transmission, and best overall image fidelity obtainable. With a superior 5-element design and Ultra™ Multi-Coatings on every surface, they outperform other "name" brand 4-element models. Wide 52° field of view. Removable contoured rubber eyeguard. The 5mm and 3.8mm feature advanced 7-element designs with surprisingly long eye relief. Guaranteed to knock your socks off!

Medium-High Power 5-Element 1.25"

20mm #8566, 15mm #8568, 10mm #8570, 7.5mm #8572 **$89 each** (3.45)

Wide-Field 5-Element 1.25"

25mm #8564	**$99** (3.45)
30mm #8562	**$119** (3.45)
35mm #8560	**$139** (3.45)

High-Power 7-Element Long Eye Relief 1.25"

5mm #8574	**$109** (3.45)
3.8mm #8576	**$109** (3.45)

UltraZoom™ 7–21mm

Owning an UltraZoom is like having a whole eyepiece collection in one ocular! Features a fully coated 7-element lens system and a 3-to-1 zoom ratio, from 7mm (65° apparent field) to 21mm (35°). 1.25" barrel.

#8556 **$179** (3.67)

Orion Explorer™ Multi-Coated .965" & 1.25" Eyepieces

These fine-quality multi-coated eyepieces offer great performance at Orion's low direct-discount price. Black-anodized, internally blackened, threaded for filters (except 40mm .965").

.965" Kellner and Achromatic Huygenian
K 18mm #8584, K 25mm #8585, AH 40mm #8586
$39.95 each (2.98)

.965" Orthoscopic
5mm #8580, 7mm #8581, 9mm #8582, 12.5mm #8583
$54.95 each (2.98)

1.25" Kellner
6mm #8536, 9mm #8538, 12mm #8540, 18mm #8508, 25mm #8510, 40mm #8512
$49.95 each (2.98)

1.25" Orthoscopic
5mm #8500, 7mm #8502, 9mm #8504, 12.5mm #8506, 18mm #8524, 25mm #8526
$59.95 each (2.98)

✧ *Sirius*™

Quality Plössl 1.25" Eyepieces

Fantastic Fully Coated Eyepieces at an Incredibly Low Price!

You could pay nearly twice the price for "famous name" Plössl eyepieces, but why? Sirius Plössls are top-quality, 50° apparent-field (43° 40mm) eyepieces that yield extremely sharp images of impressively high contrast. Ideal for all types of telescopes. The classic 4-element Plössl design is renowned for its fantastic performance. The Sirius Plössl's fully-coated optics are mounted in black-anodized aluminum housings with chrome-plated brass barrels for durability and precision fit. Available in 1.25" barrels only.

7.5mm #8738, 10mm #8736, 12.5mm #8726, 17mm #8734, 20mm #8733, 26mm #8732	**$49.95 each** (3.45)
32mm #8728, 40mm #8730	**$59.95 each** (3.67)
Custom Field Case *(holds up to four eyepieces except for the 32 mm or 40mm)*	#5911 **$12.95** (2.19)

Illuminated Reticle Eyepieces

Great for astrophoto guiding, polar alignment, and other uses. All models illuminated with a night-vision red LED.

12mm Kellner 1.25"
Double crossline reticle, fixed brightness. Plugs into power panel drive bases.
#8482 **$79.95** (3.45)

12mm Kellner Wireless 1.25"
Same as #8482 except wireless. Needs two SR-44 batteries, not included.
#8481 **$99** (3.45)

12.5mm Plössl Wireless 1.25"
With fully adjustable brightness control. Double crossline reticle. Batteries included.
#8484 **$129** (3.45)

9mm Orthoscopic Wireless 1.25"
Bull's-eye within crosshairs, adjustable brightness. Needs two SR-44 batteries, not included.
#8488 **$149** (3.67)

Orion Barlow Lenses

Double or even triple the power of your eyepieces, maximizing the versatility of your collection. Available in .965", 1.25", and 2" diameters.

Fully Baffled 2x Barlow
Multi-coated, with internal baffling to block transmission of stray light. Premium performance at a remarkable price.

.965"	#8740	**$39.95** (2.98)
1.25"	#8746	**$49.95** (2.98)
2"	#8724	**$89.95** (3.95)

VariPower 2x–3x Barlow
Our most versatile barlow. Adjusts to any magnification between 2x and 3x. Fully multi-coated optics. 1.25" barrel.
#8748 **$69.95** (3.45)

Shorty™ Barlows
About half the length of our regular barlows for added convenience. Magnifies 2x or 3x when positioned behind or in front of diagonal, respectively, on a refractor or Schmidt-Cassegrain. Works in all scopes, including those in which longer barlows won't work.

.965"	#8710	**$49.95** (2.98)
1.25"	#8711	**$49.95** (3.45)

Filters

Orion Light-Pollution Filters

Essential equipment for today's astronomer, Orion light-pollution filters enhance deep-sky views from light-polluted skies. Sophisticated multilayer technology absorbs offending wavelengths, for maximum contrast. Orion filters consistently outperform competing brands!

SkyGlow™ Broadband Filters

Rated the #1 broadband filter by *Sky & Telescope* (7/95): " I Found the Orion SkyGlow to be the most useful."
For slightly to moderately light-polluted areas.

.965" Broadband Filter fits .965" eyepieces.
#5661 **$44.95** (2.98)

1.25" Broadband Filter fits1.25" eyepieces.
#5660 **$69.95** (3.45)

2" Broadband Filter fits 2" eyepieces.
#5659 **$109** (3.45)

SC Broadband Filter fits rear cell of Meade and Celestron Schmidt-Cassegrain scopes.
#5658 **$89.95** (3.45)

UltraBlock™ Narrowband Filters

"The UltraBlock gave superior results." *Astronomy* (2/91)
For severely light-polluted areas and faint nebulae.

.965" UltraBlock Filter fits .965" eyepieces.
#5655 **$79.95** (2.98)

1.25" UltraBlock Filter fits 1.25" eyepieces.
#5654 **$99.95** (3.45)

2" UltraBlock Filter fits 2" eyepieces. #5657

SC UltraBlock Filter fits rear cell of Meade and Celestron Schmidt-Cassegrain scopes.
#5656 **$149 each** (3.67)

Moon Filters

Cuts 87% of the light from the Moon, reducing glare to reveal more detail and help preserve night vision.

.965" #5664, **1.25"** #5662
$15.95 (2.43)

Glass Solar Filters

Full-aperture optical glass filters, for superb images and safe viewing of the Sun. Great for both visual and photographic use. Fits over front of telescope.

For 8" Schmidt-Cassegrains	#7713	**$129** (4.05)
For 10" Schmidt-Cassegrains	#7715	**$139** (4.05)
For 8" Deep Space Explorer	#7718	**$129** (4.05)
For 10" Deep Space Explorer	#7719	**$129** (4.05)

Many other sizes available. See our free catalog for details

Color Eyepiece Filters

Made from absolutely the highest-quality photo-grade optical glass, anti-reflection coated. Ideal for contrast-enhancing planetary and lunar observations and photography with any telescope. Black-anodized aluminum cell threads into any standard eyepieces, or into our universal camera adapters.

.965" Set of 4 #80A Blue, #58 Green, #25 Red, #15 Yellow. #5510

1.25" Starter Set of 4 #80A Blue, #58 Green, #25 Red, #15 Yellow. #5514

1.25" Expansion Set of 4 #21 Orange, #47 Violet, #11 Yellow-Green, #82A Pale Blue. #5516

1.25" Advanced Set of 4 #8 Yellow, #23A Light Red, #38A Deep Blue, #56 Light Green. #5570

$49.95 each (2.98)

2" Set of 4 Includes #80A Blue, #58 Green, #21 Orange, and #12 Yellow.
#5513 **$99.95** (2.98)

Individual Filters
.965" and 1.25" **$14.95**. 2" from **$32.50**

Observing Aids

Eyepiece & Accessory Cases

With patented unbreakable latches, die-cut foam inserts. (Inside dimensions shown)

Small Case (shown) 11"x7"x3"
#5951 **$19.95** (2.78)

Medium Case 12.5"x9"x5"
#5952 **$27.95** (3.36)

Large Case 16"x11"x5"
#5953 **$42.50** (5.19)

Orion FlexiShield™ Dew Caps

Fights moisture buildup. Flexible black material fits snugly around scope tube; Velcro fastener. Rolls up or flattens for convenient storage and travel. Models to fit most telescopes.

8" Celestron/Meade SC #4200 **$44.95** (2.98)

Other sizes available for scopes 3.5" to 14".
See our free catalog for details.

Orion Dew Zapper™

Gently warms perimeter of corrector plate, eliminating dew buildup without "heat wave" disturbances.

8" Dew Zapper fits Meade & Celestron 8" SCs
DC #3503, **AC** #3504 **$47.95** (2.98)

10" Dew Zapper fits all Meade 10" SCs
DC #3506, **AC** #3508 **$54.95** (2.98)

11" Dew Zapper fits all Celestron 11" SCs
DC #3510, **AC** #3512 **$59.95** (2.98)

Night-Vision Flashlights

An essential accessory for astronomers. Many more in our catalog.

Nitewriter Pen	#5709	**$10.95** (1.79)
Hands-Free Flex Light	#5707	**$19.95** (2.43)
Celestron LED Light	#5720	**$21.95** (2.43)
Starlite LED Flashlight	#5714	**$24.95** (2.43)

Observer's Chairs

Standard Model Adjustable-height center column and padded seat.
#5935 **$34.95** (4.70)

Deluxe Model Built for professional musicians. Extra heavy-duty.
#5934 **$98.50** (8.02)

Telescope Covers and Tote Bags

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All our scope totes and covers are made of rugged, water-resistant nylon, and are heavily stitched to last.

Soft Scope Cases

These heavily foam-padded carrying cases are real space-savers! Zipper access, with accessory pouch (SC models only) and strap handles.

For SkyView 90mm	#15146	**$98** (4.45)
For SkyView 4.5"	#15148	**$98** (4.45)
For Celestron C5 & Meade 2045D	#15142	**$109** (4.45)
For Celestron and Meade 8" (except LX200)	#15141	**$139** (4.98)
For Meade 8" LX200	#15144	**$149** (4.98)

Dobsonian Tote Bags

Holds Orion Deep Space Explorer tubes. May also fit some home-built Dobsonians. Nylon drawstring closure. Black nylon shoulder straps.

6" DSE Bag 10"x10"x60"	#15150	**$49.95** (3.41)
8" DSE Bag 12"x12"x62"	#15151	**$54.95** (3.41)
10" DSE Bag 14"x14"x68"	#15152	**$64.95** (3.54)

Tripod & Wedge Bags

Designed to hold Schmidt-Cassegrain tripods and wedges. Handy carrying straps.

Economy Tote and Storage Bag Inexpensive reinforced tote bag without padding. Zippered pocket, nylon drawstring. Length 4' 2", width 1' 5".
#15095 **$34.95** (3.41)

Lightweight Tripod Bag Fits the Celestron lightweight tripod for C5 and C8+ telescopes (without the wedge). Zippered closure. Inside pocket.
#15143 **$43.95** (3.26)

Field Tripod and Wedge Bag For Celestron or Meade standard tripod and wedge combinations (not Meade Superwedge or Celestron Ultima wedge). No need to remove the wedge from tripod. Length 4' 2", width 1' 10".
#15096 **$79.95** (5.19)

Deluxe Tripod and Wedge Bag Fits Ultima tripod with wedge attached.
#15140 **$109** (5.19)

Scope Caps for Deep Space Explorers

Water-resistant soft nylon cap, may also fit other comparably sized Newtonian tubes.

For 6" Deep Space Explorer	#15180	**$6.50** (2.19)
For 8" Deep Space Explorer	#15181	**$8.95** (2.19)
For 10" Deep Space Explorer	#15182	**$10.95** (2.19)
For 12.5" Deep Space Explorer	#15183	**$14.95** (2.19)
For 16" Deep Space Explorer	#15184	**$18.95** (2.19)

Scope Saver™ Telescope Covers

Water-resistant blue nylon hood protects your scope from the elements. Nylon drawstring closure with cord lock.

For Dobsonian Telescopes Covers entire tube and base. Great for keeping it covered while not in use, or during transport. Fits Standard or Premium Deep Space Explorers, Newtonian tube assemblies, or home-built telescopes.

6" Std. 9"x12"x54"	#15135	**$34.95**	(2.43)
8" Std. 10"x14"x54"	#15136	**$39.95**	(2.43)
10" Std. 12"x14"x55"	#15137	**$50.95**	(2.43)
10" Prem. 12"x12"x64"	#15154	**$59.95**	(4.98)
12.5" Prem. 17"x17"x74"	#15155	**$69.95**	(3.54)
16" Prem. 20"x20"x84"	#15156	**$96.95**	(4.45)

For SCs and Small Equatorial Telescopes
Fits over the optical tube either on or off the tripod.

8" SC Model Fits any Celestron or Meade 8" Schmidt-Cassegrain telescope. 10"x12"x34"
#15130 **$33.95** (2.43)

10"–11" SC Model Fits Meade 10", Celestron Ultima 11" (not original C-11), and Celestron CG-11 telescopes. 14"x16"x44"
#15131 **$39.95** (2.43)

4.5"–6" Model Fits 4.5" to 6" Newtonian reflectors, such as SkyView 4.5, Celestron 4.5, C6. 6"x22"x38"
#15134 **$37.95** (2.43)

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Binoculars

Orion 50mm Vista™

A top-quality astronomical binocular, the Vista features BAK-4 prisms and fully multi-coated optics for high-fidelity images. Long 16mm eye relief and roll-back eyecups for eyeglass wearers. Weighs just 28 oz. Includes hard carrying case.

7x50 6.0° field of view #9355 **$219** (5.19)

10x50 5.3° field of view #9353 **$219** (5.19)

7x50 Adlerblick Binoculars

Incredible wide-field eyepiece design. Fully multi-coated. BAK-4 prisms make the 7x50 Adlerblick rival European brands selling for many times the price. 7° field of view, 26mm eye relief , 7.14mm exit pupil. Soft roll-down rubber eye-guards. Weighs 28 oz.

#9612 **$299** (5.28)

Orion 50mm Explorer™

High-performance, economical binoculars with BAK-4 prisms and multi-coatings. Great for both stargazing and daytime viewing. Rubber body coating for sure grip.

7x50 #9306 **$129** (4.44)

10x50 #9308 **$129** (4.44)

Orion 50mm UltraView™

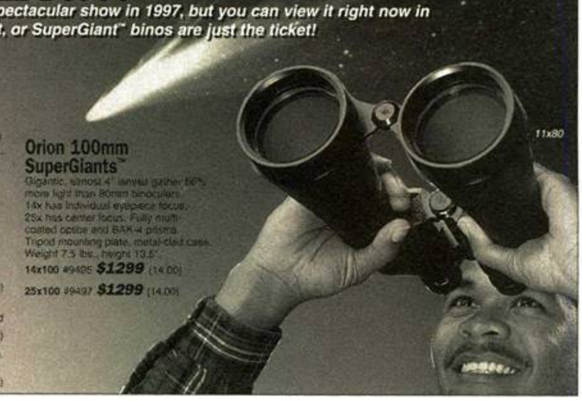
The perfect binocular for eye- and sunglass wearers. Extra-long 23mm eye relief and unique pop-down eye-piece guard. Fully multi-coated optics for high light transmission and maximum contrast. BAK-4 prisms. Close focus 16'. Weighs 32 oz.

7x50 #9357 **$179** (4.95)

10x50 #9351 **$179** (4.95)

CATCH COMET HALE-BOPP!

Hale-Bopp promises to put on a spectacular show in 1997, but you can view it right now in binoculars. Our Little Giant™, Giant, or SuperGiant™ binos are just the ticket!



Orion 70mm Little Giants™

The standard for hand-holdable high-power astronomy binoculars. Fully multi-coated. Terrific brightness and edge sharpness! Weighs only 58 oz. Includes tripod mounting adapter and deluxe hard case.

10x70 #9501, **14x70** #9494 **$369** (6.97)

Orion 80mm Giant Binoculars

For jaw-dropping views of the heavens and Earth, our wide-aperture Giants can't be beat. Fully multi-coated optics and BAK-4 prisms provide fantastic contrast and edge sharpness. 20% more light transmission than "fully-coated." Includes deluxe hard case with handle and shoulder straps.

11x80 Brightest, widest field available. Ideal for deep-space observation under dark skies. Hand-holdable. #9502 **$469** (8.05)

20x80 Highest-power model, perfect for smaller deep-space objects and long-range daytime views. Tripod required. #9498 **$469** (8.05)

16x80 Excellent for astronomy and daytime observation. Tripod recommended. #9496 **$469** (8.05)

Orion 100mm SuperGiants™

Gigantic, almost 4" lenses gather 56% more light than 80mm binoculars. 14x has individual eyepiece focus; 25x has center focus. Fully multi-coated optics and BAK-4 prisms. Tripod mounting plate, metal-clad case. Weight 7.5 lbs., height 13.5".

14x100 #9495 **$1299** (14.00)

25x100 #9497 **$1299** (14.00)

Quality Components

6x30 Achromatic Finder Scopes

6x30mm Includes 2-ring metal bracket, fits scopes 6"–12". #13023 (white) **$49.95** (3.41)

6x30mm Right-Angle Prism for right-angle viewing. Includes bracket. #13021 (white) **$79.95** (3.41)

Large-Aperture Finder Scopes

High-quality finders at very reasonable prices! Wider apertures for brighter views. Fully coated achromatic optics with adjustable focus. Precision crosshairs. White or black enameled metal tube. (Mounts sold separately.)

8x50mm Bright 6.25mm exit pupil. #7090 (white) #7094 (black) **$79.95** (3.41)

8x50mm Illuminated Wireless illuminator with adjustable brightness. #7092 (white) #7096 (black) **$119** (3.41)

9x60mm 44% more light grasp than 50mm models. #7091 (white) #7095 (black) **$119** (3.41)

9x60mm Illuminated Wireless illuminator with adjustable brightness. #7093 (white) #7097 (black) **$159** (3.41)

Low-Profile Helical Focusers

Economical yet precise focusing. Ideal for fast optical systems. Cast aluminum base with threaded, machined aluminum inner tube.

1.25" Helical Focusers #13014 **$39.95** (2.45)

2" Helical Focusers #13016 **$59.95** (2.98)

Rack-and-Pinion Focusers

Finest in their class! Diagonal-cut plated brass racks, oversized knurled knobs, long-focus travel.

1.25" #13007 **$69.95** (2.98)

2" includes 1.25" adapter #13003 **$119** (3.95)

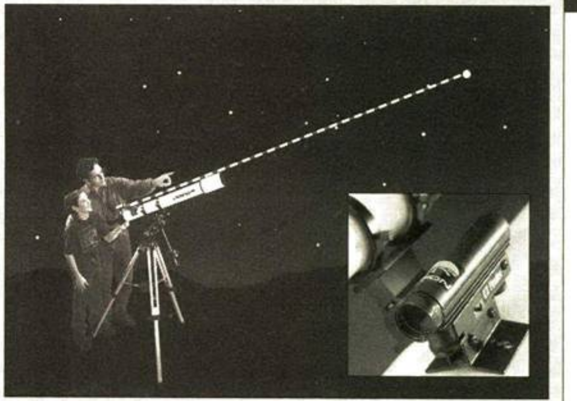
Dovetail Mounts for 50mm and 60mm Finder Scopes

Instantly install or remove your finder, without tools, without disturbing alignment! Black-anodized aluminum fits any scope 6" or larger including Celestron and Meade Schmidt-Cassegrains.

8x50mm mount #5040 **$39.95** (2.45)

9x60mm mount #5041 **$47.95** (2.98)

Extra mount base #5050 **$14.95** (2.19)



EZ Finder™ Reflex Sight

This nifty device makes pointing a telescope almost as easy as pointing your finger. Keep both eyes open and look through EZ Finder, and you'll see the image of a red dot projected at infinity, showing exactly where the telescope is aimed in the sky. Installs on any telescope in minutes. Wide 10° field of view, low and high brightness settings. Fits Meade and Celestron Schmidt-Cassegrain scopes in existing mounting holes; attaches easily to other scopes. Weighs just 2.5 oz.

#7075 **$49.95** (3.45)

Parabolic Primary Mirrors

Excellent hand-figured parabolic mirrors guaranteed to meet theoretical limits of resolution. Fine-polished, coated twice: with aluminum and silicon monoxide. Very competitively priced!

Standard Primary Mirrors
Fine soda-lime plate glass, 1:8 thickness ratio. Guaranteed ±1/8 wave. Sizes: 4.5" f/10, 6" f/8, 8" f/6, 10" f/4.5, 10" f/5.6, 12.5" f/4.8. *Call for pricing.*

Pyrex Low-Expansion Mirrors
Fine annealed Pyrex brand low-expansion glass, 1:6 thickness ratio. ±1/10 wave. Available with standard or 94% reflectivity, enhanced aluminum coatings. Sizes: 6" f/5, 6" f/8, 8" f/6, 10" f/4.5, 10" f/6, 12.5" f/6, 16" f/4.5. *Call for pricing.*

Elliptical Secondary Mirrors

Fine annealed Pyrex brand glass, aluminized and SiO overcoated. ±1/10 wave accuracy. Available with standard- or high-reflectivity enhanced aluminum coatings. Ten sizes from 0.75" to 4.00" minor axis. *Call for pricing.*

Astrositall Zero Expansion Mirrors

Astrositall is a glass-ceramic material with an ultra-low coefficient of thermal expansion. Ideal for harsh environmental conditions. 1:7 thickness ratio, ±1/10 wave surface accuracy. Enhanced aluminum coatings.

Astrositall Parabolic Mirrors 6" f/8, 6" f/5, 8" f/6, 10" f/6

Astrositall Elliptical Flat Mirrors 1.30", 1.52", 1.83", 2.14". *Call for pricing.*

We also carry Sonotube Newtonian optical tubes, Dob altitude bearings, mirror cells, and other telescope components. See our catalog.

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Lots More Accessories in Our 100-Page Color Catalog!

Orion accessories are absolutely guaranteed to be the finest quality available. Compare them side-by-side with higher-priced brands!

Universal Camera Adapters

For prime focus or eyepiece projection astrophotography.

.965" #5268 **$27.95** (2.98)

1.25" #5264 **$29.95** (2.98)

Hybrid 1.25"/.965" #8782 **$29.95** (2.98)

Variable-Power Camera Adapter

Allows variable projection distances during eyepiece projection photography. For 1.25"eyepiece holders.

#5262 **$39.95** (2.98)

Orion Slow-Motion Adapter

Attaches to your photo tripod pan head. Two slow-motion control knobs to make precision adjustments in altitude and azimuth. Very handy for tracking planets, the Moon, and constellations with refractor telescopes and small spotting scopes. Attaches with a standard 1/4-20 thread.

#7033 **$39.95** (2.19)

Tele-Extenders for Schmidt-Cassegrain Scopes

For high-powered photography with your Meade or Celestron 4", 8", 10", 11", 14" Schmidt-Cassegrain.

Standard Tele-Extender #5125 **$29.95** (2.98)

Variable Tele-Extender #5127 **$39.95** (2.98)

T-Adapters for SC and MAK

Threads to rear cell of telescope, requires T-ring for your camera model.

For SC #5116 **$26.95** (2.98)

For C90 #7115 **$34.95** (2.98)

T-Rings for 35mm Cameras

Available for many different camera types; call toll-free or see our catalog for your particular model.

45° Correct-Image Diagonal Prisms

Ideal for all refractors and compound telescopes used for terrestrial viewing.

.965" Diagonal #8791

1.25" Diagonal #8790

Hybrid 1.25"/.965" #8792

$44.95 each (3.45)

90° Star Diagonal Prisms

Orion's multi-coated diagonals are ideal for refractors and Schmidt-Cassegrains.

.965" Star Diagonal #8761 **$29.95** (2.98)

1.25" Star Diagonal #8763 **$39.95** (2.98)

Hybrid 1.25"/.965" #14008 **$39.95** (2.98)

Orion Ultra™ 2" Diagonals

2" Prism Diagonal Absolutely the finest-quality multi-coated 2" prism for highest light transmission.

For refractors #8770, **for Schmidt-Cassegrain** #8771 **$219** (4.71)

2" Mirror Diagonal Affordable, high-quality first-surface optical flat star diagonal.

For Schmidt-Cassegrain #8772 **$109** (3.45)

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Electronic Finder & Sky Catalog

Let Sky Wizard do the work, while you relax and have fun observing!

- Find any celestial subject in 15 seconds!
- One minute set-up—no polar alignment or levelling.
- Observe hundreds of objects in just a few hours!
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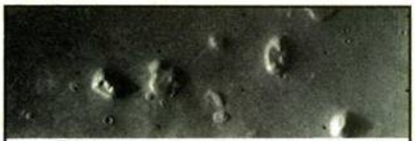

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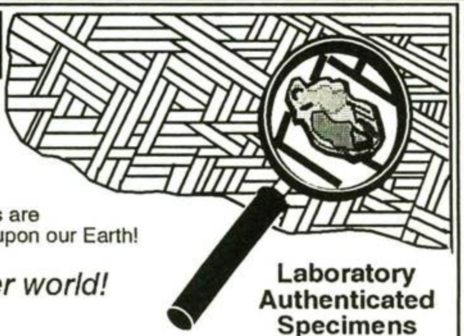

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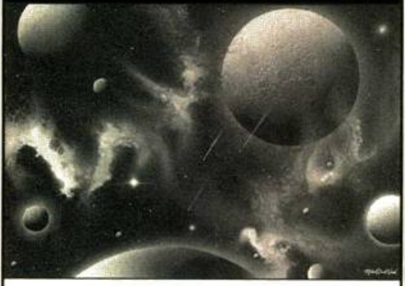

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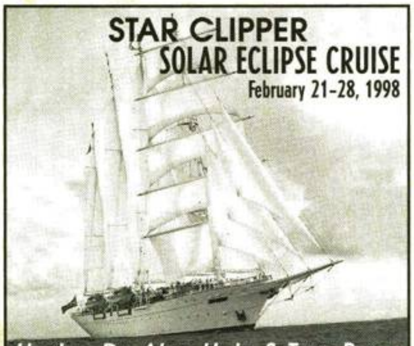

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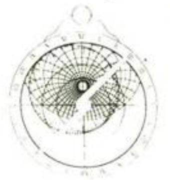

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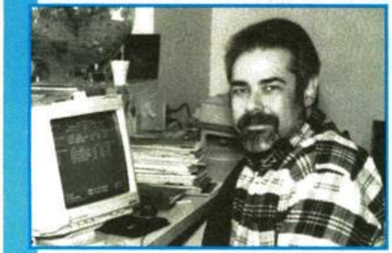

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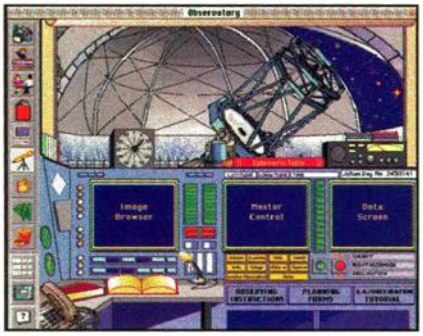

Astronomy Village
NASA CORE, Lorain County JVS, 15181 Route 58 South, Oberlin, OH 44074, (216) 774-1051 ext. 293, fax (216) 774-2144. Price: $5; $5 for the teacher's guide; $14 for the introductory video; $4.50 shipping per order (in the U.S. only). Minimum requirements: Macintosh LC III, System 7, 5 MB of memory, 20 MB on a hard drive, color monitor, CD-ROM drive, and Hypercard 2.1.

Astronomy Village is a nicely done multimedia package that engages students in the scientific process as applied to astronomical research. As part of NASA's Classroom of the Future project, the program is geared toward 9th grade students but could be used at other levels. Adults may find the lectures, tutorials, application software, and research projects educational and fun, too.

Teachers break students into research teams consisting of researchers, observers, and data analysts. An orientation center provides tutorials for each of the team members about what their jobs are and how to accomplish their part of the project. Lectures from astronomers introduce four research areas and 10 individual projects, such as search for supernovae, search for planetary companions, observatory site selection, and wedges of the universe.

Each project team has a mentor, provided by video clips of a real astronomer. The team can refer to their logbook, consult a research plan, and get help from their mentor as they puzzle their way through the project. Trips to a hands-on lab, a computer lab, an observatory, a conference center, and an auditorium in the Astronomy Village help the team assemble observations, background material, and reduce their data as they progress toward solving their problem. Some of the stops provide research tools such as calculators, library browsers, computer simulations, and NIH Image, an image-processing program complete with tutorials.

Although a research plan is provided, students don't need to follow it and can follow their own leads. After all, science isn't always a linear a, b, c, d, e process; sometimes researchers find themselves following c, b, d, a, e. But in case a team gets mired down or lost, "e-mail" messages and helpful hints from the mentor guide the team toward the goal. The help points the team in the right direction but is careful not to provide pat answers.

The research experience is closely duplicated as students must fill out observing forms, discuss their data, and then present their conclusions to their classmates. It is quite likely that two teams could work on the same project and come to different conclusions, presenting a useful class debate.

Hands-on activities accompany the computer presentation so students aren't glued to a monitor. A mock press conference provides some pointed questions to get the team to think about what their results mean in broad terms. The teacher's guide isn't an absolute necessity to run the program or follow the hands-on activities, but it provides some additional material and summarizes some points of the presentation, making it a useful tool.

Considerable thought went into this program. The mentors' and other astronomers' video and audio clips

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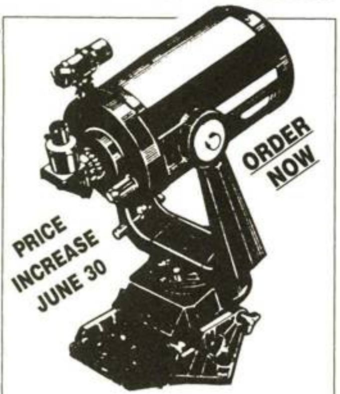

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hit the right tone. The use of real research areas and applications such as NIH Image convey the idea that this is real science the students are exploring. I heartily recommend the program to educators and to students and adults who want to deepen their knowledge of how astronomical research is done. — Dave Bruning

StarClock 2.0

Leos Ondra, Brno, Czech Republic. Freeware available from ftp://ftp.coast.net/SimTel/msdos/astrnomy/sclock20.zip. Minimum requirements: IBM PC-compatible computer, DOS, and VGA graphics.

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This is an excellent program for anyone wanting to learn more about how stars changes as they age. StarClock is now a staple in my astronomy software list. □

Software developers may send new programs and upgrades to AstroBytes, Astronomy Magazine, P.O. Box 1612, Waukesha, WI 53187-1612 or e-mail bytes@astronomy.com. Check out Astronomy's home page at http://www.kalmbach.com/astro/astronomy.html

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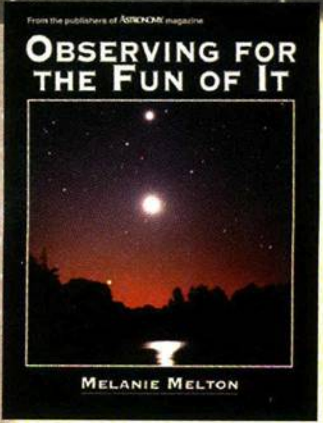
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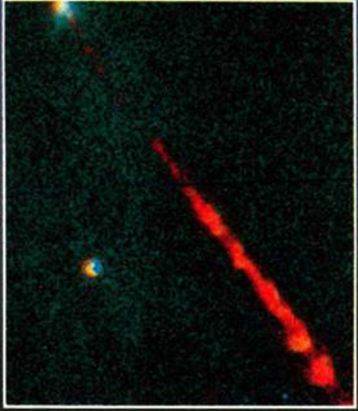
JULY 1996

ISSUE OF

ASTRONOMY



Jeff Hester, Arizona State University

FROM ASHES TO STARS

Astronomers have changed their ideas about stars gently forming from collapsing gas clouds. The real story is a violent one of vast outflows, whirling disks, and hypersonic jets.

HALE-BOPP BRIGHTENS

Now that Comet Hyakutake has whetted our appetites, it's time to turn our attention to Comet Hale-Bopp as it reaches naked-eye visibility this summer.

IS ANYBODY OUT THERE?

Although the media and much of the public seem to think the Galaxy teems with civilizations, life — and particularly intelligent life — may be exceedingly rare.

A FISHEYE ON THE SKY

Fisheye lenses offer a unique perspective by capturing the entire night sky. Here's how to shoot these stunning 180° photos.

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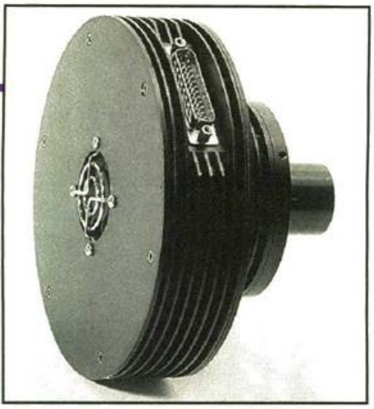
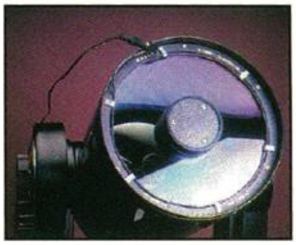
NEW PRODUCTS



Improved CCD Camera

Santa Barbara Instrument Group (SBIG) introduces the ST-6A, an improved version of the ST-6 camera that's been on the market for five years. The ST-6A is 0.8 inch thinner and has a side-mounted connector rather than rear, as with the ST-6. This makes the camera easier to use with fork-mounted Schmidt-Cassegrain telescopes. The camera also threads directly into an SCT for prime-focus photography, thanks to a T-thread nose piece. A built-in fan chills the camera 5° C cooler than ambient temperature. A ¼ x 20 tapped hole lets the ST-6A mount on a camera tripod.

Santa Barbara Instrument Group, 1482 East Valley Road, P.O. Box 50436, Santa Barbara, CA 93150; (805) 969-1851; fax, (805) 969-4069. The ST-6A CCD Camera: $2450.



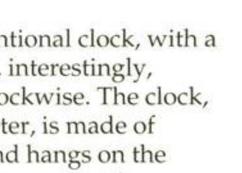
Dew-fighting System

The Dry Eye Telescope Dew Control System accommodates up to five heat ropes that plug into one control unit, which runs on a 12-volt battery you provide. For SCT owners, the heat loop rests against the corrector plate's surface to keep it dry. Adhesive tabs affix this rope to the plate's retaining cell. SCT kits include a control unit plus heated loops for an eyepiece, the corrector plate, a Telrad, and an 8x50 finder. Dry Eye Technologies also sells kits for all Dobsonian and Newtonian telescopes on the market.

Harrison Company, 2574 Granville St., Vancouver, BC V6H 3C8 Canada; orders, (604) 737-4303; information, (604) 888-1505. 8-inch SCT kit: $175 (Canadian funds); 10-inch SCT: $185 CDN; 11-inch SCT: $200 CDN; 14-inch SCT: $210; Dobsonian/Newtonians: $50 to $100, CDN. Extra eyepiece heater loops: $5 CDN.

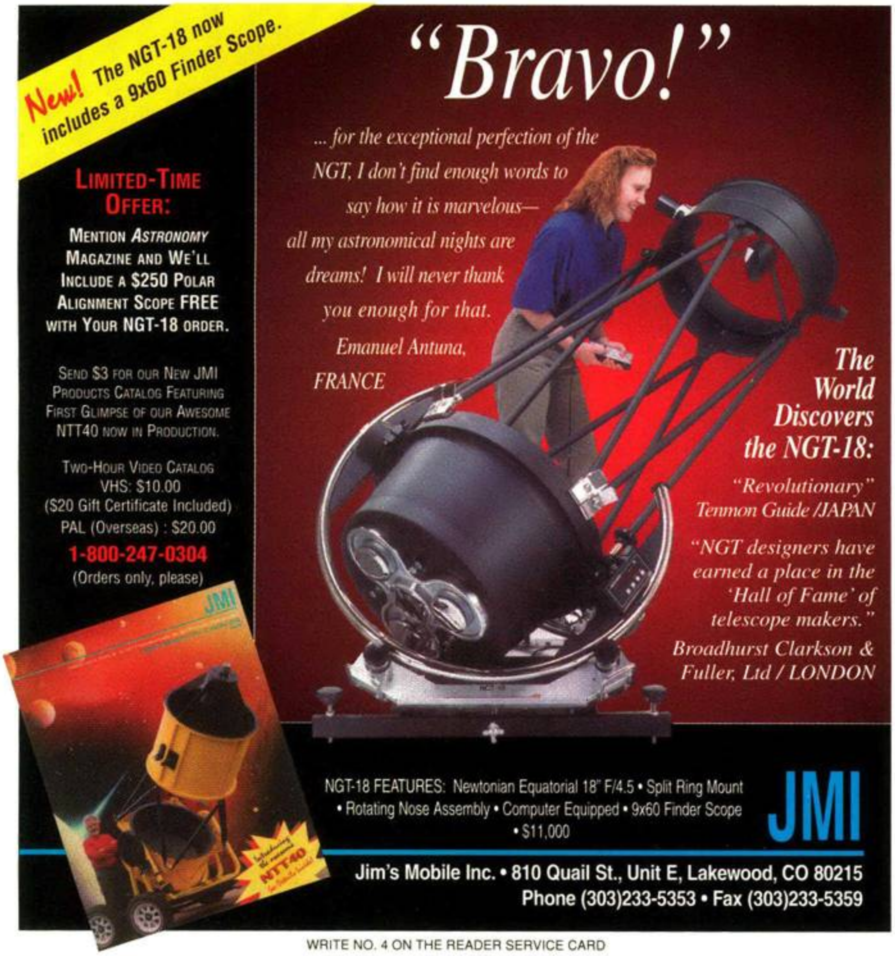
New Products presents announcements issued by manufacturers. ASTRONOMY assumes no responsibility for the product information supplied. Prices are suggested retail. Suppliers should send announcements and color photographs to the attention of John Shibley, P.O. Box 1612, Waukesha, WI 53187, or newprod@astronomy.com.

Day and Night Clock



The New Earth Clock shows local time for anywhere in the world, as well as the approximate location of day and night. Tell time by reading a 24-hour time scale that surrounds a circular political map, which revolves once a day. Arrows arranged on the map every 15° point out local time for every time zone around the world. The time scale is divided into 15-minute increments. This display also works as a conventional clock, with a second hand that, interestingly, sweeps counterclockwise. The clock, one foot in diameter, is made of durable acrylic and hangs on the wall. One AA battery provides power for several months.

Scientific Universe Products, 126 S. Helberta Ave, Unit #4, Redondo Beach, CA 90277; phone/fax: (310) 937-4763. The New Earth Clock: $49.



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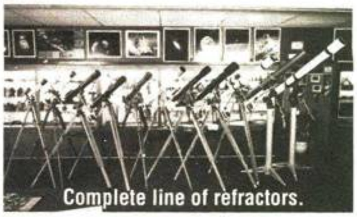

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RESOURCES & PHOTOFACTS

Magnificent Milky Way (page 32)

The Immortal Fire Within: The Life and Work of Edward Emerson Barnard, by William Sheehan (Cambridge University Press, 1995). The first full-length biography of Barnard.

Worlds Between Worlds (page 46)

"Far Journey to NEAR Asteroid" by Jim Bell, ASTRONOMY, March 1996. Describes NASA's first dedicated mission to an asteroid.

Asteroids II, edited by Richard P. Binzel, Tom Gehrels, and Mildred Shapley Matthews, (University of Arizona Press, 1989). The definitive scientific work dealing with the study of asteroids.

Night-Owl Galaxies (page 71)

The Universe from Your Backyard, by David J. Eicher (Cambridge University Press, 1988). A constellation-by-constellation tour of galaxies and other deep-sky objects . □

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p. 54: Larry Landolfi, December 1990; **p. 63:** NGC 6229 by T. L. Dessert, 10-inch f/6 scope, 103aF film, 15-minute exposure, June 6, 1978; M92 by Bill Iburg, 14-inch f/5.5 SCT, Ektachrome 400, 20-minutes with a cold camera, June 27, 1979; M13 by Bill and Sally Fletcher, 16-inch f/4.5 reflector, tricolor image on Tech Pan with 35-minute red, 45-minute green, and 70-minute blue exposures, June 10 and 11, 1994;
p. 80, top: Donald G. Burns, 10-inch SCT, Pictor 416 CCd camera, AO2 adaptive optics system, infrared blocking filter, December 3, 1995; **middle left:** Donald Parker, taken at 9h38m UT, May 23,1995; **middle right:** Dan Schechter, 6-inch f/9 refractor using eyepiece projection with a 2.5mm eyepiece, Kodachrome 200 film, 8-second exposure, August 10, 1995; **bottom:** Donald Parker, composite taken at 7h51m UT (rings) and 8h04m UT (disk), July 4, 1995;
p. 81, top: Thomas A. Dobbins, 36-inch Lick refractor at 588x and 1,186x at 10h05m UT, August 11, 1995; **bottom:** Thomas A. Dobbins 36-inch Lick refractor, Wratten #21 orange filter at 11h08m UT, August 9, 1995.

MEETINGS & EVENTS

June 7-8
Astronomy Festival of Red Rock State Park, Sedona, Arizona. Sponsored by the Sirius Lookers of Sedona and the Verde Valley Astro club. Contact Russell A. Nidey, 1101 Zalesky Rd., Cottonwood, AZ., 86326, (520) 634-7332; or Dennis Young P.O. Box 87, Sedona, AZ 86339.

June 7-9
1st Latin American Workshop on Comets, Buenos Aires, Argentina. Contact the Asociacion Argentina Amigos de la Astronomia, Av. Patricias, Argentinas 550, 1405 Capital Federal, Argentina, 541-863-3366, cometwor@aaaa.org.ar.

June 8-15
6th Annual Grand Canyon Star Party, South and North Rims of the Grand Canyon, Arizona. Sponsored by the Tucson Amateur Astronomy Association. Contact TAAA, 1122 East Greenlee Place, Tucson, AZ 85719, (520) 293-2855, ketelsen@as.arizona.edu.

June 14-16
Jersey Star Quest VI, Beemerville 4-H Camp, Sussex, New Jersey. Sponsored by the Amateur Astronomers Association of Princeton, Inc. Contact Greg Mauro, Jersey Star Quest VI, 4 Crosswicks Court, Trenton, NJ 08610, (609) 585-9465.

June 14-15
26th Annual Apollo Rendezvous and Telescope Fair, Dayton Museum of Natural History, Dayton, Ohio. Cosponsored by the Miami Valley Astonomical Society and the Dayton Museum of Natural History. Contact John Schroer, MVAS, 2600 Deweese Parkway, Dayton, OH 45414, (513) 275-7431, ext. 36, jschroer@usa.pipeline.com.

June 14-16
WOW, Hartman Creek State Park, near Waupaca, Wisconsin. Sponsored by the Northeast Wisconsin Stargazers. Contact Don Wyman, 1065 Laager Lane, Oshkosh, WI 54901, (414) 233-3083, dwyman@athenet.net.

June 15
Annual Solstice Star Party, Northern Cross Observatory, Hartland, Michigan. Sponsored by the Warren Astronomical Society. Contact Doug Bock, Warren Astronomical Society, P.O. Box 1505, Warren, MI 48090-1505, (810) 750-0273.

June 15
June Star B-Q, Blue Canyon, California. Sponsored by the Sacramento Valley Astronomical Society. Contact Ray Gray, SVAS, P.O. Box 575, Rocklin, CA 95677-0575, (916) SVAS-111

June 16-22
Solstice Markers and the Anasazi Sky, Cortez, Colorado. Sponsored by Crow Canyon Archaeological Center. Contact CCAC, 23390 Road K, Cortez, Colorado, 81321, (800) 422-8975, ext. 146.

June 17-23
Ninth IUAA General Assembly, Luzern, Switzerland. Sponsored by the Internal Union of Amateur Astronomers. Contact Andreas Tarnutzer, IUAA, Hirtenhofstrasse 9, CH-6005 Luzern, Switzerland.

June 18-21
General Assemblies and Congress on Amateur Astronomy Today, Lucerne, Switzerland. Sponsored by the International Union of Amateur Astronomers. Contact Andreas Tarnutzer, Hirtenhofstrasse 9, CH-6005 Luzern, Switzerland.

June 29
How Things Fly, National Air and Space Museum, Washington, D.C. Contact the National Air and Space Museum, Office of Public Affairs, MRC 321, Room 3733, Washington, DC 20560, (202) 357-1552. □

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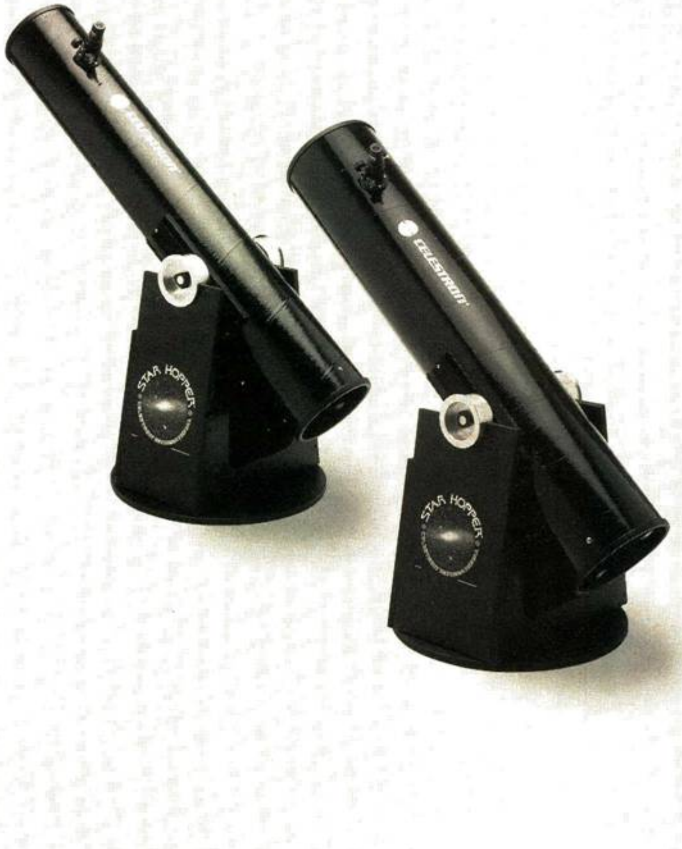

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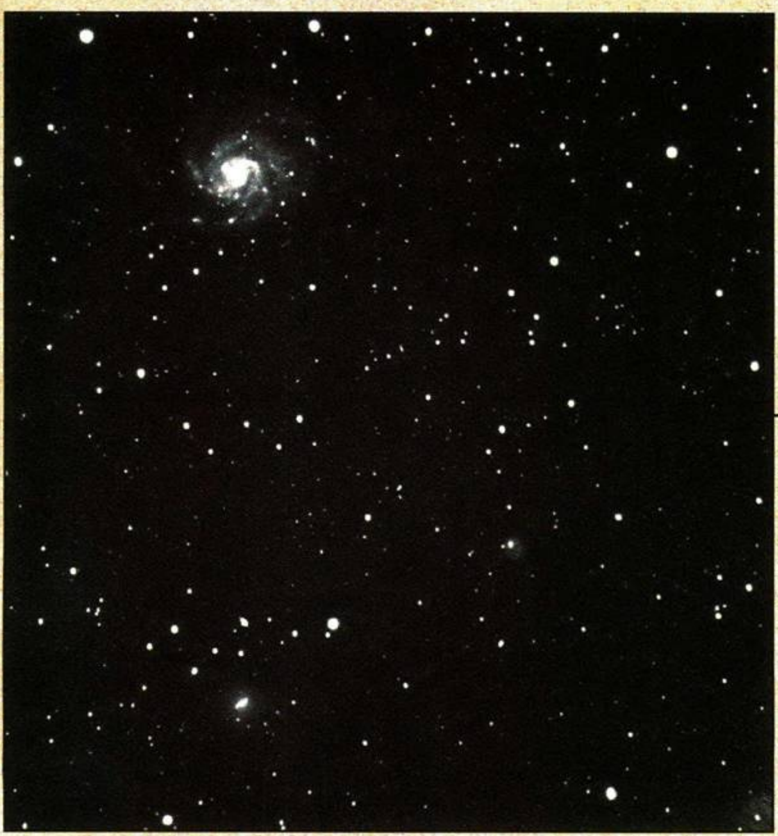
READER REPORTS

Hey Mom, I Discovered a Comet. . . .

Between following the two headline comets of last winter, Hale-Bopp (1995 O_1) and Hyakutake (1996 B_2), Houston amateur Ed Szczepanski found his own comet, a respectably bright object designated 1996 B1. "I discovered this comet on a photograph taken on January 27 at the Houston Astronomical Society's site just west of Columbus, Texas," says Szczepanski. "I was taking a photo of the galaxy M101 with a 4-inch refractor, and a cold front had just passed through the area. The temperature was about 29° F, and the sky was exceptionally transparent.

"The photo of M101 was the last one I took that night," Szczepanski continues. "After sleeping for three hours, I developed the negative right in my RV on site, and came across a fuzzy object south of M101. I suspected it was a comet. Luckily, I had another photo of the same region and found nothing on it in that area."

Szczepanski called Larry Mitchell of the Houston Astronomical Society and asked him to search the IAU *Circulars* for any reported comets. He found none. Szczepanski, Mitchell, and several others went out the next night and, after the Moon set, located the comet near the tiny galaxy NGC 5474, visible at lower right in the photo. That same night,



The Discovery of Comet Szczepanski (1996 B_1), lower left, and M101

by Ed Szczepanski (4-inch refractor, hypersensitized Tech Pan 6415 film, 50-minute exposure taken January 27, 1996)

Venus, Mars, Jupiter, and the Moon (l. to r.)

by Frank Zullo (180mm lens at f/2.8, Fuji Provia 200 film, 4-second exposure taken November 23, 1995)

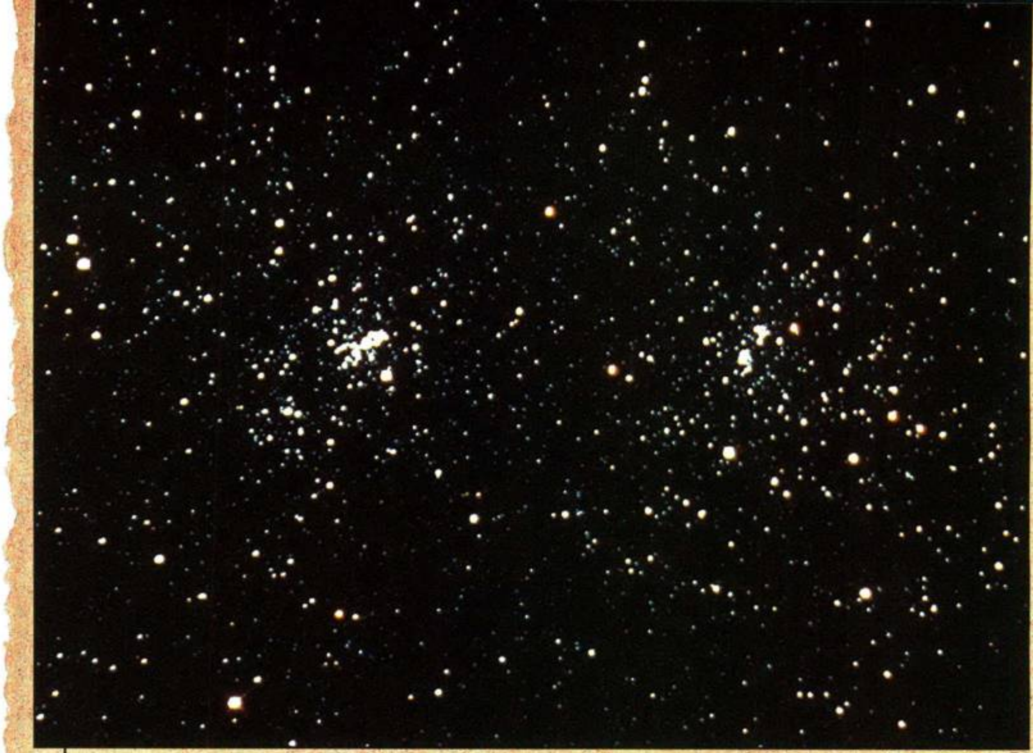
A Perseid Meteor Slips Past the Andromeda Galaxy

by Greg White (50mm lens at f/4, Ektachrome P1600 film, 2-minute exposure taken at the 1995 Stellafane convention) comet observer Alan Hale in Cloudcroft, New Mexico, spotted the comet with 10x50 binoculars.

Young Moon Record Broken. "A group of us saw a crescent Moon from Sentinel, Arizona, last night, whose age was 12½ hours. The currently recognized record was 13h 42m, by Robert C. Victor." With those words, Tom Polakis of Tempe, Arizona, described the youngest Moon observation yet, January 21, 1996. "The Moon was first sighted by Pierre Schwaar," he continued, "using a 10-inch telescope at 60x. Conditions could not have been better, with fine transparency and excellent seeing right down to the horizon."

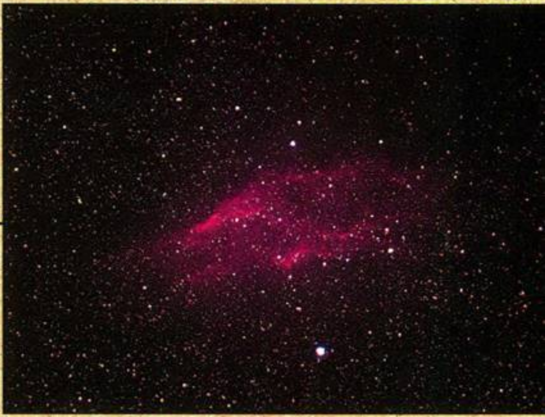
Jovian Moons in the Daytime. On August 12, 1995, amateurs in the Houston, Texas, area celebrated Astronomy Day. They set up telescopes at the George Observatory and viewed Jupiter, among other sights. Richard Nugent of Houston reports that a number of observers focused on Jupiter around 6:40 p.m. CDT, in daylight, with Dennis Zwicky's 17.5-inch reflector. Not only did they observe Jupiter's creamy disk, but they also spotted a Galilean moon. "After looking carefully, by about 6:45 p.m., we spotted a total of three moons," says Nugent. ☐

ASTRONOMY wants to hear about your observations of the sky. Send reports, sketches, photographs, and disks to David J. Eicher, Reader Reports Editor, ASTRONOMY, P.O. Box 1612, Waukesha, WI 53187–1612. Please label each photo with photo data, name, address, and social security number. You may send written reports and images via the Internet to: rreports@astronomy.com



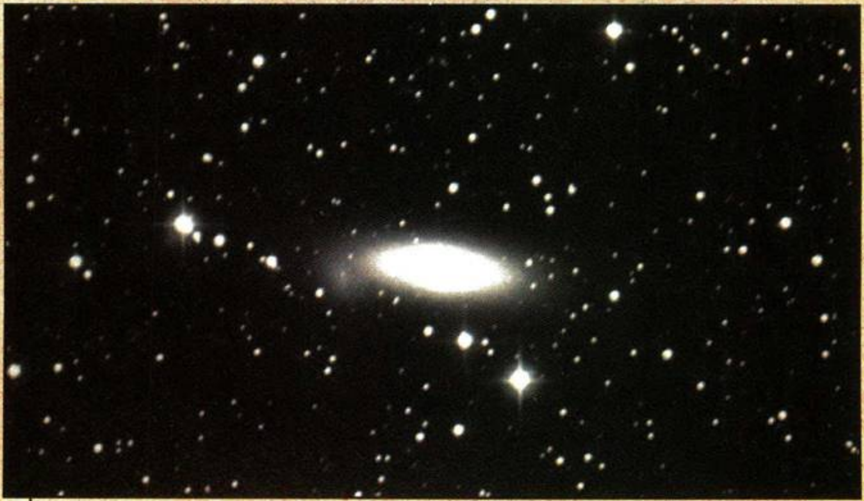
The Double Cluster in Perseus

by Lee C. Coombs
(10-inch f/5 reflector, Ektachrome P1600 film, 20-minute exposure)



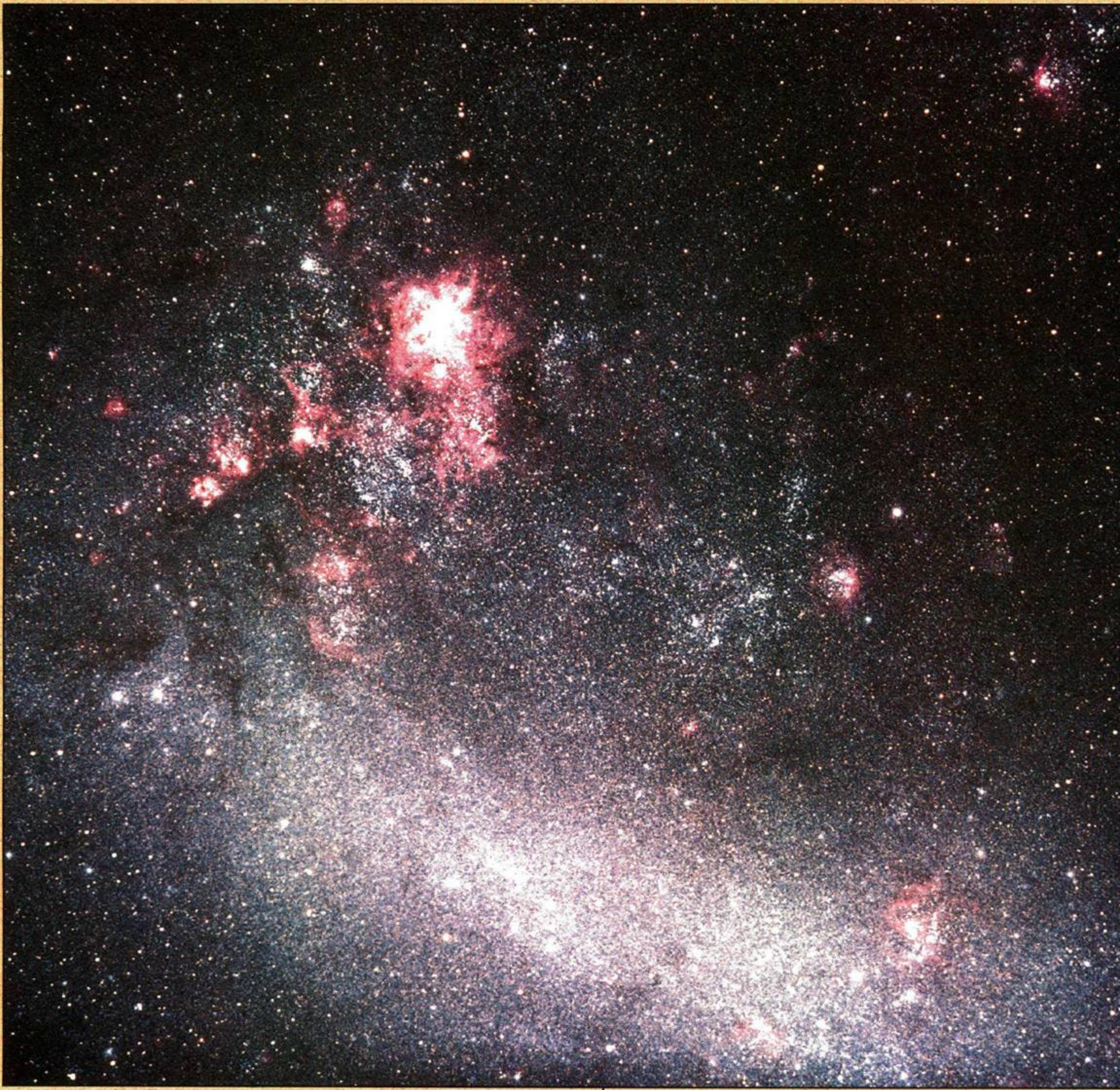
The California Nebula (NGC 1499)

by Vince and Maggie Farnsworth
(4-inch f/5 refractor, Fuji SG 800 film, composite of two 45-minute exposures)



Elliptical Galaxy NGC 1023 in Perseus

by Martin C. Germano
(14.5-inch f/5 reflector, hypersensitized Tech Pan film, 120-minute exposure)



The Large Magellanic Cloud and Tarantula Nebula

by Luke Dodd
(4.7-inch f/8.5 refractor, hypersensitized Fujicolor 400 film, composite of two 60-minute exposures)

Space Shuttle Endeavour Re-entering over Tucson

by Daniel D. Durda

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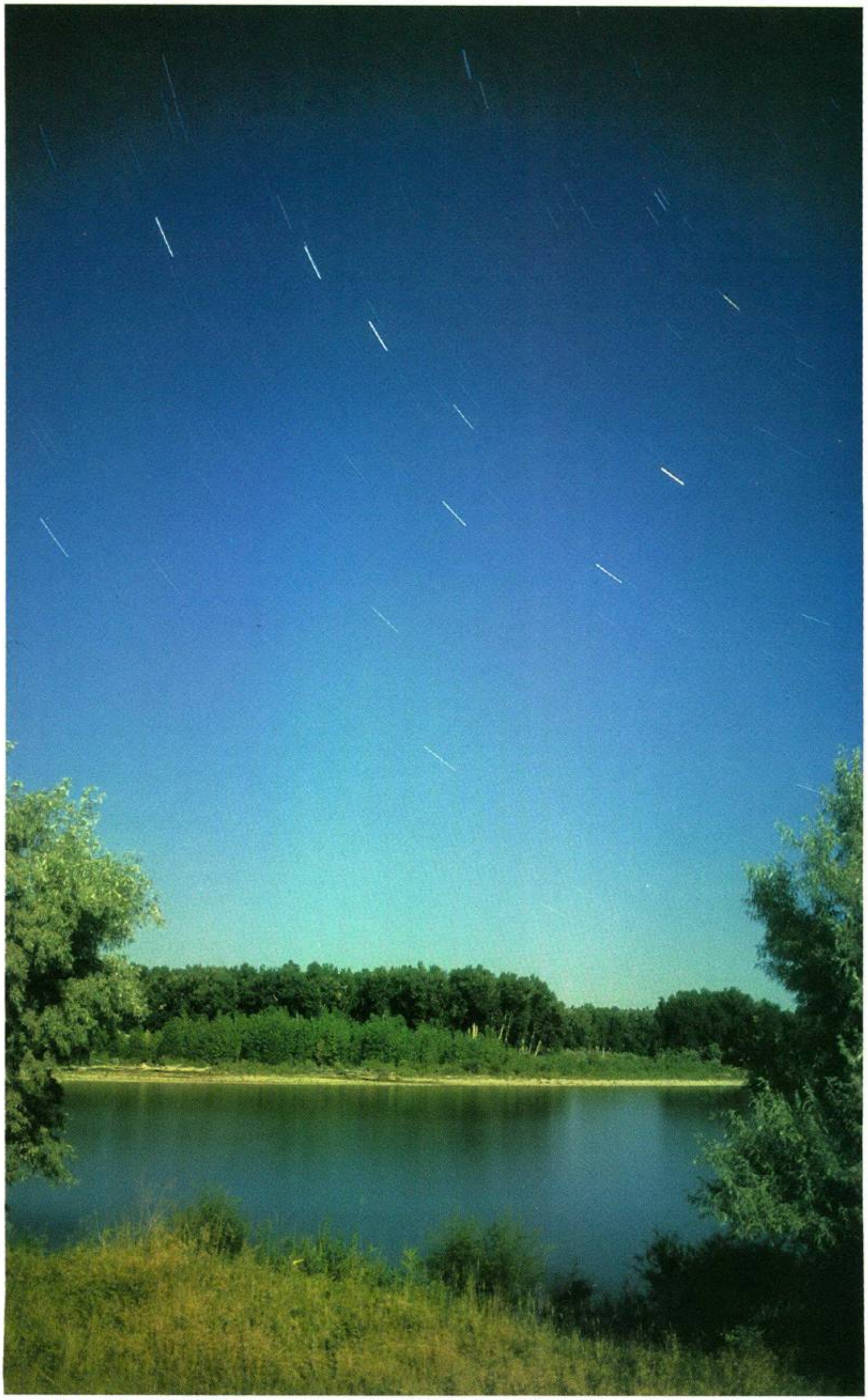

The Big Dipper Wheels above the Yellowstone River

by John McNeal (50mm lens at f/2.8, Fuji 50 ISO film, 12-minute exposure taken August 11, 1995)

McNeal parked his tripod-and-camera combination near the river outside Pompeys Pillar, Montana, demonstrating how a simple astrophoto can pack a beautiful punch. Moonlight illuminated the landscape during the 12 minutes of exposure time.

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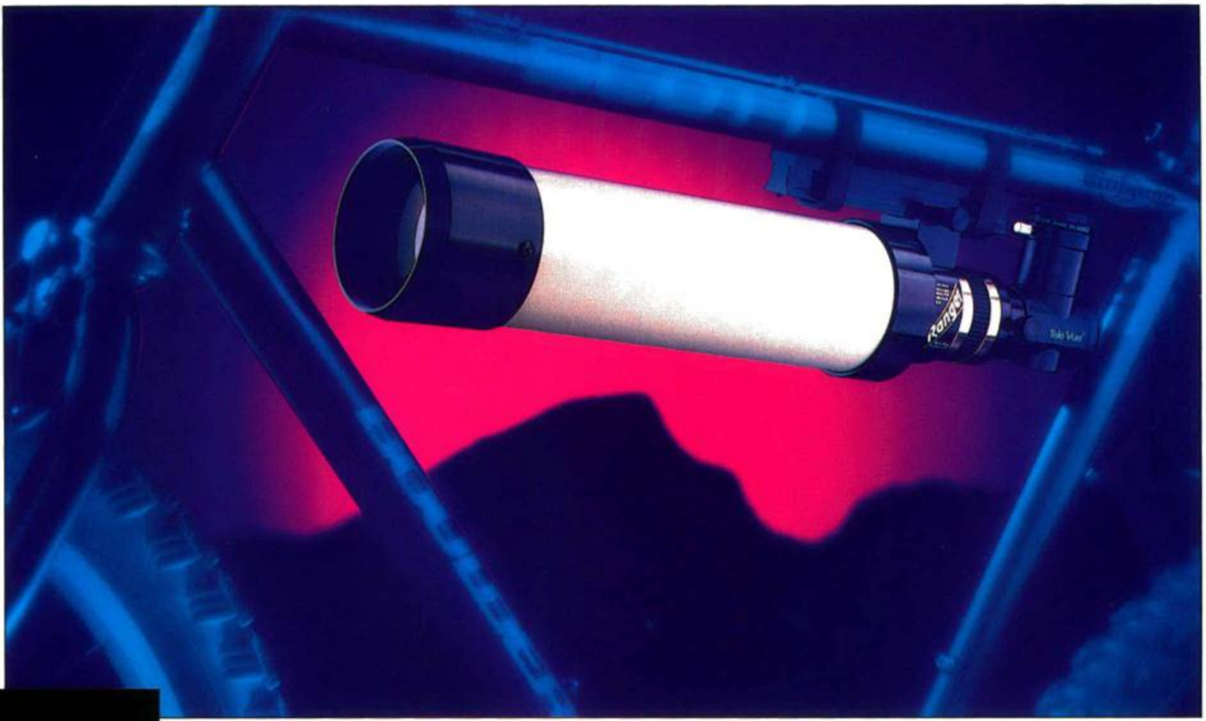

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